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# LIMITED EVALUATION OF THE TACTICAL FLIGHT COMBAT SUIT IN THE F-16

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December 1989

Final Report

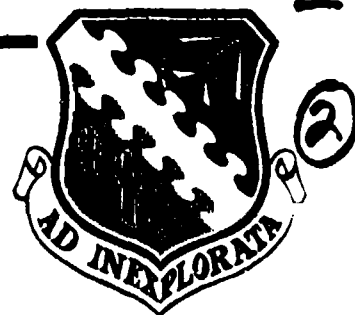
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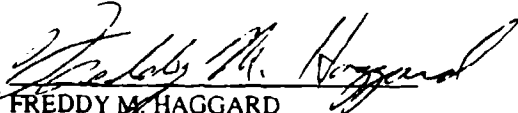
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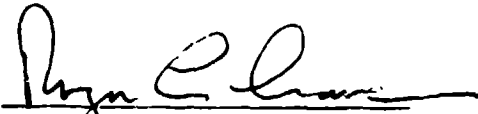
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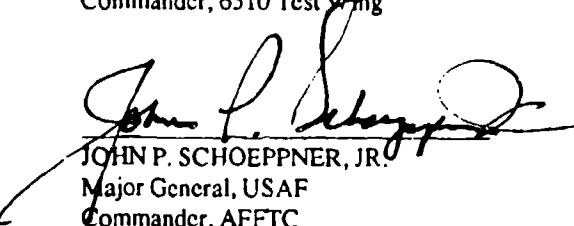
  
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## PREFACE

This report presents the results of a limited subjective evaluation of an aircrew protection ensemble, the Tactical Flight Combat Suit (TFCS), with comparison to an aircrew pressure breathing for g's ensemble flown in the F-16 aircraft. The TFCS was intended to protect aircrew members from high sustained positive acceleration (g), cold water immersion, and heat stress. Testing was conducted at the Air Force Flight Test Center (AFFTC) by the F-16 Combined Test Force using an F-16B aircraft. The

Human Systems Division, Brooks AFB, Texas, requested testing of the TFCS in the F-16B through Program Introduction Document P-88-07-05, 24 June 1988, and testing was conducted in accordance with AFFTC Test Information Sheet FA-1016 (Reference 1).

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## EXECUTIVE SUMMARY

This report presents the results of a limited evaluation of the Swedish developed Tactical Flight Combat Suit (TFCS). The TFCS was subjectively compared to the unique pressure breathing for g's (PBG) ensemble, the F-16/PBG. A total of five F-16/PBG ensembles had previously been produced exclusively for the F-16 Combined Test Force (CTF) to use in support of high-g loads and performance missions in the F-16. This test was conducted to evaluate the advantages and disadvantages of the TFCS, in comparison to the F-16/PBG, in the 9 g environment of a high performance fighter aircraft. Ground and flight evaluations were conducted by the F-16CTF at the Air Force Flight Test Center (AFFTC), Edwards AFB, California from 21 June 1989 to 24 August 1989 at the request of the Human Systems Division (HSD/YAL), Brooks AFB, Texas. There were fifteen flights required to complete the test.

The TFCS used in this test was an integrated life support ensemble designed to provide pilots protection from sustained high-g, cold water immersion, and temperature stress. Components of this modular flight ensemble included a unique lightweight helmet, low profile high pressure oxygen mask, an integrated full coverage anti-g and immersion suit, hoses for suit ventilation, wear protective trousers, and a specialized anti-g/survival vest. The F-16/PBG, a modified derivative of an ensemble previously tested at the AFFTC, was a one-piece flight suit with standard anti-g suit bladder coverage over the lower body, chest counterpressure bladder coverage over the upper torso, and a unique mask and helmet designed to protect pilots from sustained high-g only. The test aircraft was a two-seat F-16B, USAF S/N 81-0816, modified to accommodate either the TFCS or the F-16/PBG. The overall objective was to subjectively evaluate the

TFCS in a high-g environment. Ground test objectives included assessing the TFCS for ease of donning and doffing, mobility, comfort, cockpit fields of view, and functional compatibility with the F-16. Flight test objectives included evaluating the TFCS for anti-g protection, assessing operational cockpit fields of view, cockpit compatibility, and comfort.

The objectives of the TFCS tests were met. In general, the TFCS was more effective than the F-16/PBG in providing aircrews anti-g protection in the sustained high-g environment. It was a significant improvement over the standard issue anti-g suit (CSU-13B/P). The TFCS was bulkier and more restrictive of movement than the F-16/PBG. With design improvements around the joints and waist, freedom of movement could be comparable to the F-16/PBG. Despite the TFCS vapor barrier, the two ensembles caused comparable levels of sweating, due to the effectiveness of the ventilation system of the TFCS. Overall, pilots rated the TFCS helmet and mask better than the F-16/PBG helmet and mask. The TFCS system offered improved fields of view, greater noise attenuation, and both clear and tinted visors. The TFCS lacked the desirable automatic mask tensioning system present in the F-16/PBG helmet and mask. This feature improved mask comfort in-flight because the mask was automatically tightened to the pilot's face during periods of high-g. A significant finding of this test was that anti-g and anti-exposure (immersion) suit features may be successfully incorporated into one flight ensemble. The USAF should pursue the development of a flight ensemble that combines anti-g and anti-exposure protection for use by fighter pilots flying in conditions that currently require the use of the CW-21/P anti-exposure suit.

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# INTRODUCTION

## GENERAL

This report presents the results of a limited subjective evaluation of the Tactical Flight Combat Suit (TFCS). Testing included comparison of the TFCS with a pressure breathing for g (PBG) protection ensemble (F-16/PBG) being used by the F-16 Combined Test Force (CTF) in an F-16C at the Air Force Flight Test Center (AFFTC). The TFCS, a Swedish developed modular flight ensemble, was designed to protect pilots from sustained high positive acceleration (g), cold water immersion, and heat stress. The Swedish Air Force had flown the TFCS to 8 g's. The F-16/PBG was developed by the United States Air Force (USAF) from one of three ensembles previously tested at the AFFTC (References 2 and 3). This unique PBG flight ensemble was made exclusively for the F-16 CTF and consisted of a one-piece flight suit and a unique mask and helmet designed to protect pilots from sustained high-g. The F-16/PBG featured standard anti-g suit bladder coverage to the lower body, but added chest counterpressure bladder coverage to the upper torso for assisted PBG. The Human Systems Division (HSD/YAL), Brooks AFB, Texas, had requested this test to evaluate the TFCS in a 9 g environment in comparison with the F-16/PBG.

Ground and flight tests were conducted by the F-16 CTF at the AFFTC, Edwards AFB, California from 21 June 1989 to 24 August 1989. A two-seat F-16B test aircraft (USAF S/N 81-0816) was modified to accommodate either the TFCS or the F-16/PBG. Front cockpit modifications included a modified g-valve connector, positive pressure breathing system, and a ventilation system. Rear cockpit modifications included a LIFEDATA system (described in Appendix B) in addition to those listed for the front cockpit. Fifteen flights were required to complete the test. Testing the TFCS included donning and doffing, mobility, aircrew comfort, fields of view, anti-g protection, fatigue, and cockpit compatibility. Tests were accomplished in accordance with the Test Information Sheet FA-1016 (Reference 1).

## BACKGROUND

During flight in modern high performance aircraft, pilots are often exposed to hazardous environmental conditions such as reduced pressure, hypoxia,

temperature extremes, and high positive g forces. Technological advances have minimized, but not eliminated, the severity of aircrew exposure to many of these hazards (References 4 and 5). Additional improvements are needed to further improve pilots' physiological performance and reduce risks associated with flying high performance aircraft. Advances have already been made in improving anti-g protection and in modifying oxygen systems, and these advanced technologies have received limited aircraft testing (References 2, 3, and 6).

Recently, the USAF has emphasized improving anti-g suit effectiveness by increasing body surface area coverage and by providing life support hardware for assisted positive pressure breathing for g's. Other air forces are likewise investigating methods for advancing life support technology to increase pilots g tolerance. Ensembles are being developed to provide maximum anti-g coverage to the lower body and increased breathing gas pressures (up to 60 millimeters of mercury), delivered to the lungs in conjunction with chest counterpressure provided from an anti-g vest. The effect gained would be balanced internal and external chest pressure, resulting in improved systemic hemocirculation and increased blood-oxygen saturation.

The TFCS tested was an integrated life support ensemble designed to provide pilots protection from sustained high-g, cold water immersion, and temperature stress (Reference 7). Because Swedish Air Force pilots frequently fly their high performance fighter aircraft (ten out of twelve months) while wearing their anti-exposure (immersion) suit, the Swedish Air Force combined the anti-g suit with the anti-exposure suit (the TFCS). The USAF did not have protective gear that combined anti-g and anti-exposure protection in one flight ensemble. The USAF flight gear which came closest to the capability of the Swedish TFCS was the Tactical Air Force (TAF) anti-exposure "poopy" suit (CW-21/P) designed to be worn under the standard anti-g suit. In this ensemble, tactical pilots receive the standard 1950's anti-g protection to the lower body, no ventilation to reduce heat stress, and no assisted positive pressure breathing to enhance g tolerance. For this reason, and the fact

that the Tactical Air Command (TAC) continues to report Class A mishaps due to g-induced loss of consciousness (GLOC), HQ/TAC requested that the USAF develop an improved anti-g protection ensemble. This test of the Swedish TFCS provided information for development of a USAF system.

## TEST ITEM DESCRIPTION

The modular TFCS was designed to maximize aircrew protection up to 9 sustained g's, provide protection from cold water exposure, and prevent heat stress during extended wear. Components of the TFCS included a unique lightweight helmet, low profile high pressure oxygen mask, an integrated full coverage anti-g and immersion suit, hoses for suit ventilation, wear protective trousers, and a specialized anti-g/survival vest. Figure 1 shows the TFCS ensemble. Illustrations showing a pilot in varying stages of dress in the TFCS ensemble are presented in Appendix A. Inflation of the anti-g/survival vest, for providing chest counterpressure, was controlled by an on/off switch located on the cockpit panel. With this switch in the "on" position, the vest was pressurized with breathing gas from the oxygen regulator, inflating the air bladders in the anti-g vest at aircraft g levels greater than five. When this switch was in the "off" position, the vest did not inflate at any g level, and the ensemble functioned as a conventional anti-g suit.

An F-16B (S/N 81-0816) aircraft was used for this test. Both cockpits were modified to provide aircrews with PBG, a Fleisch meter to measure breathing gas flow, and a blower for flight suit ventilation. In addition, the rear cockpit was modified to accommodate a stand-alone physiological data acquisition system termed LIFEDATA (Appendix B). Data from the Fleisch flow meters and LIFEDATA were provided to USAFSAM/VNL, Brooks AFB, Texas, and the Swedish Air Force for analysis. The aircraft was flown only with wingtip missiles to maximize sustained 9 g levels. A more detailed description of the aircraft Class II modification is presented in Appendix B.

## TEST OBJECTIVES

The overall objective was to subjectively evaluate the TFCS in a sustained high-g operational environment in comparison to the F-16/PBG. Specific ground test objectives were to evaluate:

1. ease of donning and doffing,
2. mobility during cockpit ingress and egress,
3. pilot comfort during preflight inspection,
4. fields of view inside both cockpits, and
5. functional compatibility with the F-16.

Specific flight test objectives were to evaluate:

1. anti-g protection,
2. fields of view outside both cockpits,
3. comfort in flight,
4. capability to perform routine and simulated combat flight operations,
5. the TFCS ventilation system, and
6. to collect inflight physiological data for analysis by medical experts from Brooks AFB, Texas, and the Swedish Air Force.

## CONSTRAINTS AND LIMITATIONS

Nonavailability of some TFCS components and sizes made it impossible to properly fit two of the three AFFTC test pilots. Pilot B did not have a custom fit TFCS ensemble, so he used one of the Swedish pilots' TFCS mask and helmet, and another's TFCS garment. This AFFTC pilot wore his F-16/PBG mask and helmet with the TFCS garment when he flew in the front cockpit, and this Swedish pilot was in the rear cockpit during the same test flight. Pilot C had a custom fit TFCS garment, but was unable to attain an airtight seal with the TFCS mask even though he had previously been measured and fitted by Swedish life support personnel. Components needed to modify the mask to achieve the proper mask fit for pilot C were not available at the AFFTC. Therefore he used his F-16/PBG mask and helmet with the TFCS garment in place of the TFCS mask and helmet.

The TFCS had four basic features. It featured improved anti-g capability, assisted positive pressure breathing for g protection, anti-exposure protection, and air ventilation to prevent heat stress. The one-piece F-16/PBG had one additional feature that was

different from the standard anti-g suit. It had assisted positive pressure breathing for g protection. The TFCS was significantly more complex and had more components than the F-16/PBG, and this difference should not be lost in the analysis comparing the

comfort and mobility of the two ensembles. The configuration of the ensembles would have been more equal if the test subjects could have worn the CW-21/P "poopy" suit under the F-16/PBG. Poopy suits were not available to use with the F-16/PBG.

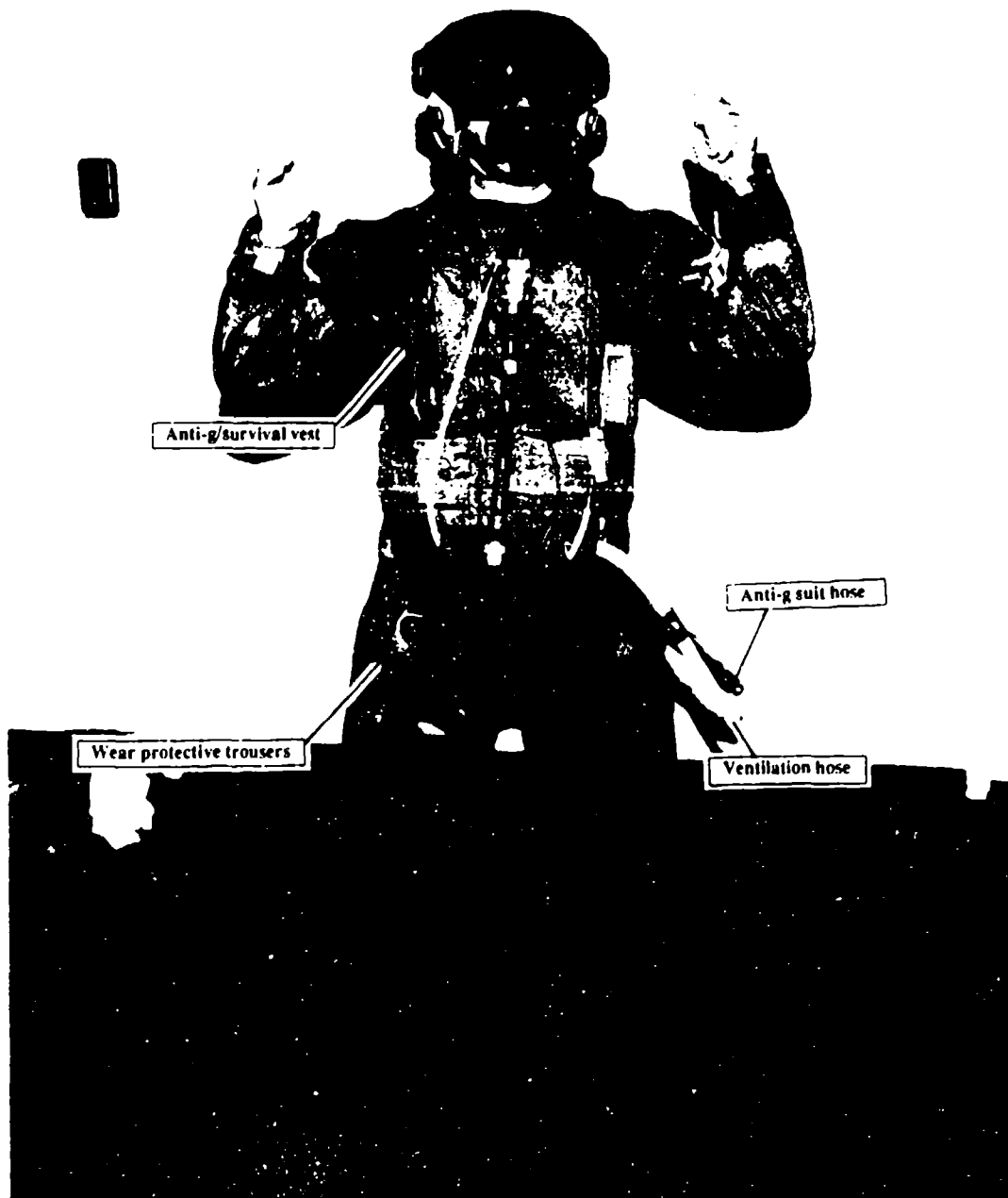


Figure 1 Tactical Flight Combat Suit

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## TEST AND EVALUATION

Overall the test activities consisted of subjectively evaluating the Tactical Flight Combat Suit (TFCS) during aircraft ground operations and during 11 sorties which emphasized sustained high-g test points and aerial combat maneuvers/basic fighter maneuvers (ACM/BFM).

Three AFFTC pilots qualified and experienced in pressure breathing for g's flew the TFCS in varying configurations. Pilot A had a well-fitted, customized TFCS ensemble. Pilot B had not been scheduled early-on as one of the AFFTC test pilots supporting this test. As a result, a customized TFCS was not available for his use. Pilot C had previously been measured for a complete customized TFCS. He was, however, unable to attain a proper mask fit/seal while wearing his TFCS mask and helmet so he wore his F-16/PBG mask and helmet instead.

Ground testing of the TFCS was performed to ensure cockpit compatibility prior to flight test. Two AFFTC pilots tested the TFCS for system design during preflight inspection of the aircraft and assessed its integration within the cockpit. Each pilot assessed the following:

1. ease of donning and doffing,
2. mobility during preflight inspection and cockpit ingress/egress,
3. comfort with respect to heat, pinching, or binding points,
4. fields of view inside front and rear cockpits,
5. visor distortion, glare, and reflection, and
6. the ventilator, g-valve, and oxygen regulator.

Each AFFTC pilot flew at least one familiarization (FAM) sortie wearing the TFCS to become familiar with the ensemble in the F-16 cockpit prior to participating in the sustained high-g test flight profiles.

The flight test matrix and flight test profiles are shown in Appendix C.

The intent of the test matrix was to exercise the TFCS in the sustained high-g and ACM/BFM flight environments. This allowed the pilots, based on their experience flying in the F-16/PBG, to assess their performance in the TFCS relative to the F-16/PBG under high-g conditions, where combat suits would be needed most. The following were evaluated in flight:

1. fit,
2. reach and mobility,
3. comfort,
4. fields of view inside and outside the cockpit,
5. visor distortion, glare, reflections, and
6. anti-g protection.

Pilots completed subjective questionnaires following each flight. The questionnaires and pilot responses are included in Appendix D.

## TEST RESULTS

The objectives of ground and flight tests were met. In general, the TFCS was more effective than the F-16/PBG for providing aircrews anti-g protection in the sustained high-g environment. The TFCS provided significant improvement in anti-g protection relative to the standard (CSU-13B/P) anti-g suit. The USAF should develop a full coverage anti-g suit for pilots flying in high performance aircraft. (R1)<sup>1</sup>

While pilot consensus was that the TFCS was more effective than the F-16/PBG in sustained high-g environments, it was bulkier and more restrictive of movement than the F-16/PBG. With design improvements around the pilot's joints and waist, freedom of movement could be comparable to the

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<sup>1</sup> Numerals preceded by an R within parentheses at the end of a paragraph correspond to the recommendation numbers tabulated in the Conclusions and Recommendations section of this report.

F-16/PBG. Despite the TFCS vapor barrier, the two ensembles caused comparable levels of sweating, due to the effectiveness of the ventilation system of the TFCS. Overall, pilots rated the TFCS helmet and mask slightly better than the F-16/PBG helmet and mask. The TFCS system offered improved fields of view, greater noise attenuation, and both clear and tinted visors. The TFCS lacked the desirable automatic mask tensioning system present in the F-16/PBG helmet and mask. This feature improved mask comfort in flight, because the mask was automatically tightened to the pilot's face only during periods of high g. A significant finding of this test was that anti-g and anti-exposure suit features may be incorporated successfully into a single effective flight ensemble. The USAF should pursue the development of a flight ensemble that combines anti-g and anti-exposure protection for use by fighter pilots flying in conditions that currently require the use of the CW-21/P anti-exposure suit. (R2)

### Ground Test:

Table 1 summarizes pilot subjective evaluations made during ground testing of the TFCS in comparison to the F-16/PBG. Ground test questionnaire responses are presented in Appendix D.

Putting on the TFCS for the first time was difficult due to the unfamiliarity and bulkiness of the ensemble. The subjective ratings in Table 1 regarding the donning/doffing of the TFCS were made shortly after the pilots first attempted wearing the protective gear. At the end of the flight test, the pilots were donning and doffing the TFCS easily, usually within five to ten minutes.

The fact that the pilots rated the F-16/PBG better relative to the TFCS for donning and doffing was anticipated because of the complexity of the TFCS. It had more features and components, and was, therefore,

**Table 1**

#### **SUMMARY OF GROUND TEST RESULTS COMPARING THE TFCS WITH THE F-16/PBG**

Evaluation Area	F-16/PBG Better	Equal	TFCS Better
Donning/Doffing - Anti-g/immersion suit - Flight boots - Anti-g vest - Helmet and mask - Parachute harness	X X	X X X	
Mobility - A/C preflight - Ingress and egress	X X		
Comfort - Outside cockpit - Inside Cockpit - Pinching and binding - Sweating	X	X X X	
Field of View			X
Visor - Distortion - Glare or reflection	X	X	
Acceptability for flight		X	

more complicated to wear. Because the TFCS was fitted snugly for maximum effectiveness, it was difficult to flex and extend the joints. For this reason, flight boots were more difficult to put on and lace up. The anti-g vest, worn over the immersion suit, was easy to don and doff.

While pilot A expressed no problems with donning the TFCS helmet, pilot B, who shared a TFCS helmet and mask with a Swedish pilot, reported difficulty in donning the TFCS helmet. Donning the TFCS helmet was accomplished by using the thumbs to spread the opening of the helmet at the edge of the earcups and moving the helmet forward in an oblique back-to-front plane, rather than in the top-to-bottom plane as was customary with the F-16/PBG helmet. The TFCS helmet was specifically designed to fit snugly against the angle of the jaw and beneath the ear to prevent it from being pulled from the pilot's head under wind blast typical of ejection. It lacked a chin strap for securing it to the pilot's head (see Appendix A, Figure A3). Pilot A, fitted with his own TFCS helmet, found it was better than his F-16/PBG helmet. Both pilots found the TFCS mask more comfortable than the F-16/PBG mask.

Pilots had to adjust the parachute harness when donning it over the bulkier TFCS. The ensemble's restrictiveness made preflight ground inspection of the aircraft, cockpit ingress and egress, and movement within the cockpit more difficult than when wearing the F-16/PBG. Pilot A experienced discomfort in the knees when inspecting the aircraft wheel wells (Figure 2). During ingress, restriction in range of motion at the knee joint made it difficult for the pilots to prevent their boots from hitting the instrument panel. In the cockpit, upper torso rotation and suit bulk made it difficult for the pilots to connect their anti-g and ventilation hoses.

The point of attachment of the oxygen supply hose to the TFCS anti-g vest interfered with the parachute harness chest buckle during strap-in. Dependent upon torso length and personal preference, pilots had to either fasten the parachute harness buckle under or over this vertical oxygen tube (Figure 3). Figure 4 shows the parachute harness buckled under the vertical oxygen tube to the anti-g vest. Furthermore, the fixed hose attachment to the anti-g vest was located too close to the chin, causing interference with head movement (Figure 4). The F-16/PBG had a swivel connection located lower on the chest and further away from the

chin, allowing for less restrained oxygen hose and head movements.

Connection fittings for attaching the oxygen hose to the anti-g vest and mask should swivel and be relocated further away from the chin. This would reduce the likelihood of the hose interfering with head movement. USAF pressure breathing for g protection developmental programs should make the vertical oxygen hose anti-g vest attachment a swivel type connection located away from the pilot's chin. (R3)

The profile of the TFCS mask allowed pilots a slightly larger field of view within the cockpit relative to the F-16/PBG mask. Figures 5 and 6 illustrate a 95th percentile (sitting height) pilot's front and rear cockpit fields of view respectively, while sitting at his usual in-flight seat position, looking at the HUD, and wearing the different masks. The areas under the hash marks denote areas obscured from the pilots' view by the mask. Similarly, a 86th percentile (sitting height) pilot drew his front (Figure 7) and rear (Figure 8) cockpit fields of view while wearing the two different masks. Again the area under the hash marks denotes areas obscured from view by the masks. Both pilots indicated that the TFCS mask improved cockpit field of view. However this improvement was somewhat offset by the bulk of the wear protective trousers worn over the anti-g/immersion suit, which slightly obscured the view of the landing gear handle and some of the cockpit caution lights. No glare or reflections were caused by the test items during ground testing. When the pilots performed the emergency ground egress procedures, they reported that the difficulty of egress was similar for the two suits. All quick disconnecting lines functioned properly, and posed no apparent safety hazard to the aircrews which could occur in the event of an actual ground emergency.

Because the F-16/PBG was less restrictive and less bulky, it was more comfortable than the TFCS when wearing it outside the cockpit. No uncomfortable binding or pinching points were noted while wearing the TFCS in the cockpit. The TFCS and F-16/PBG were considered to be equally comfortable in the cockpit. Despite the added vapor barrier component layer of the TFCS, perceived level of sweating was the same with both ensembles. The blower (ventilator) ventilated the TFCS effectively, in general circulating cool air to the body and improving the overall comfort experienced with the TFCS. Although cooling air was distributed to all parts of the body, sweating was more



Figure 2 Pre-Flight Inspection in the TTCS

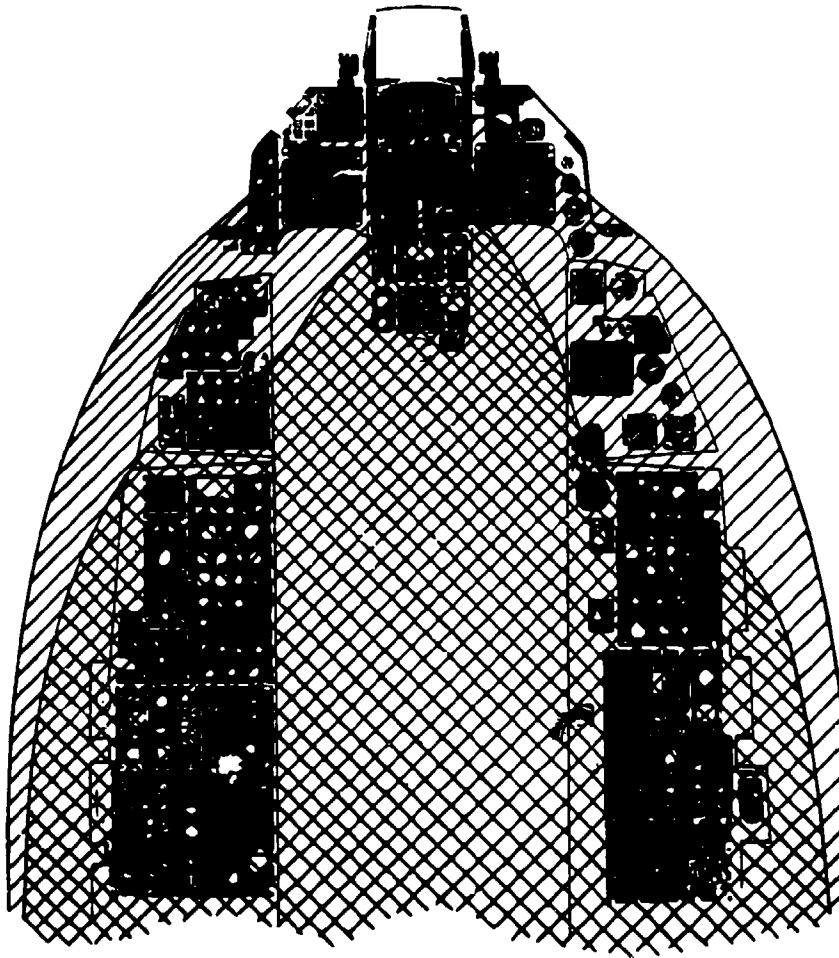


Figure 3 TFCS Rear Cockpit Strap-In



Figure 4 TFCS in Rear Cockpit

## COCKPIT FIELD OF (FOV) WORKSHEET



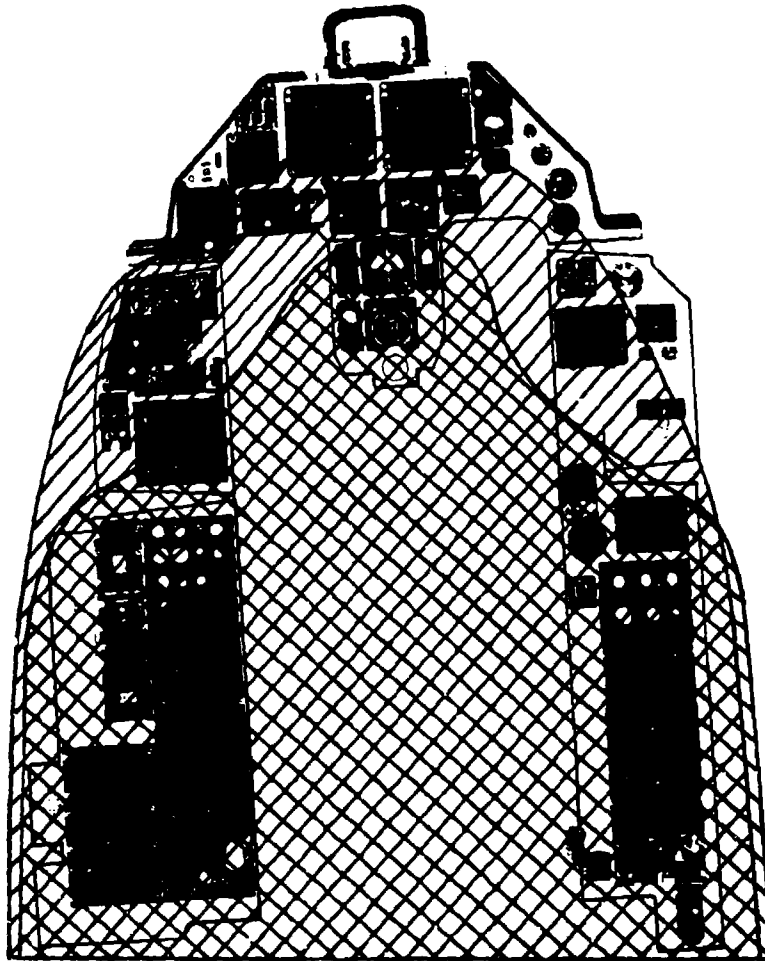
**FORWARD COCKPIT**

F-16/PBG 

TFCS 

Figure 5 Front Cockpit Fields of View - Pilot One

## COCKPIT FIELD OF (FOV) WORKSHEET



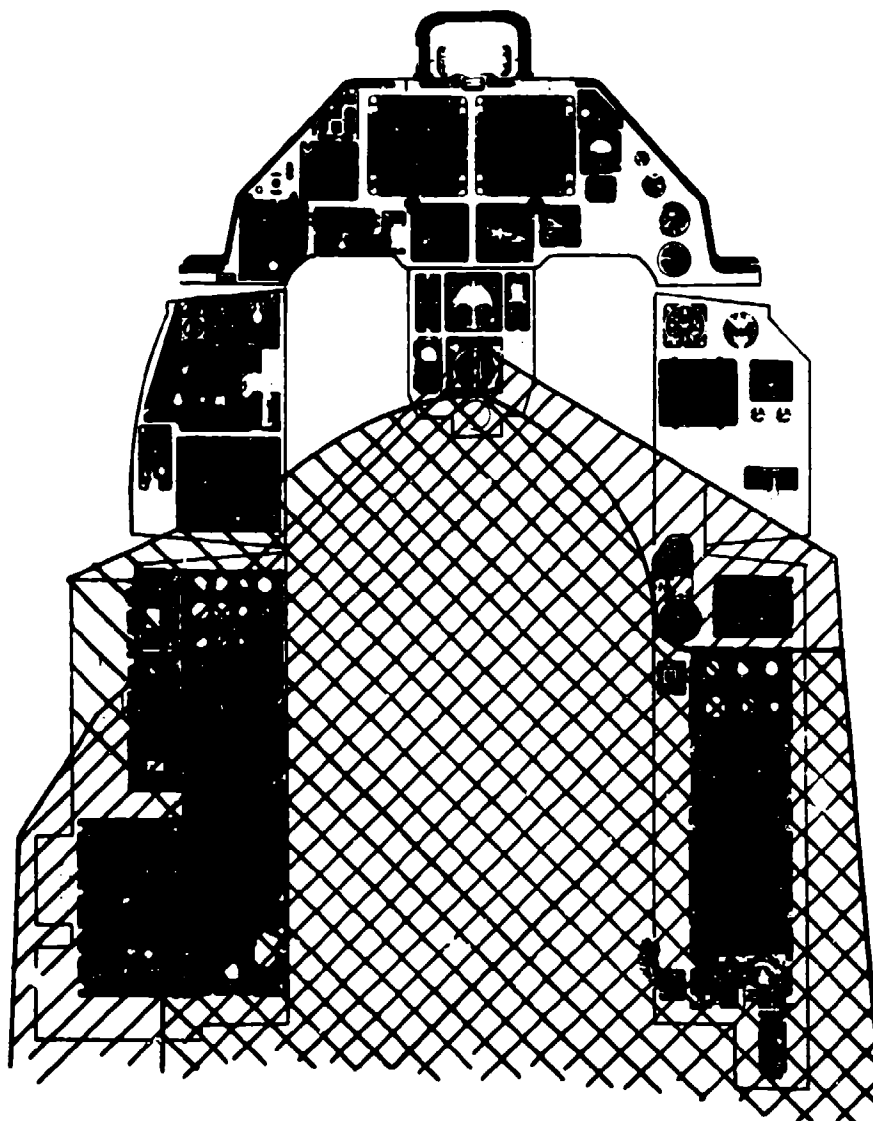
**AFT COCKPIT**

F-16/1'BG 

TFCS 

Figure 6 Rear Cockpit Fields of View - Pilot One

## COCKPIT FIELD OF (FOV) WORKSHEET



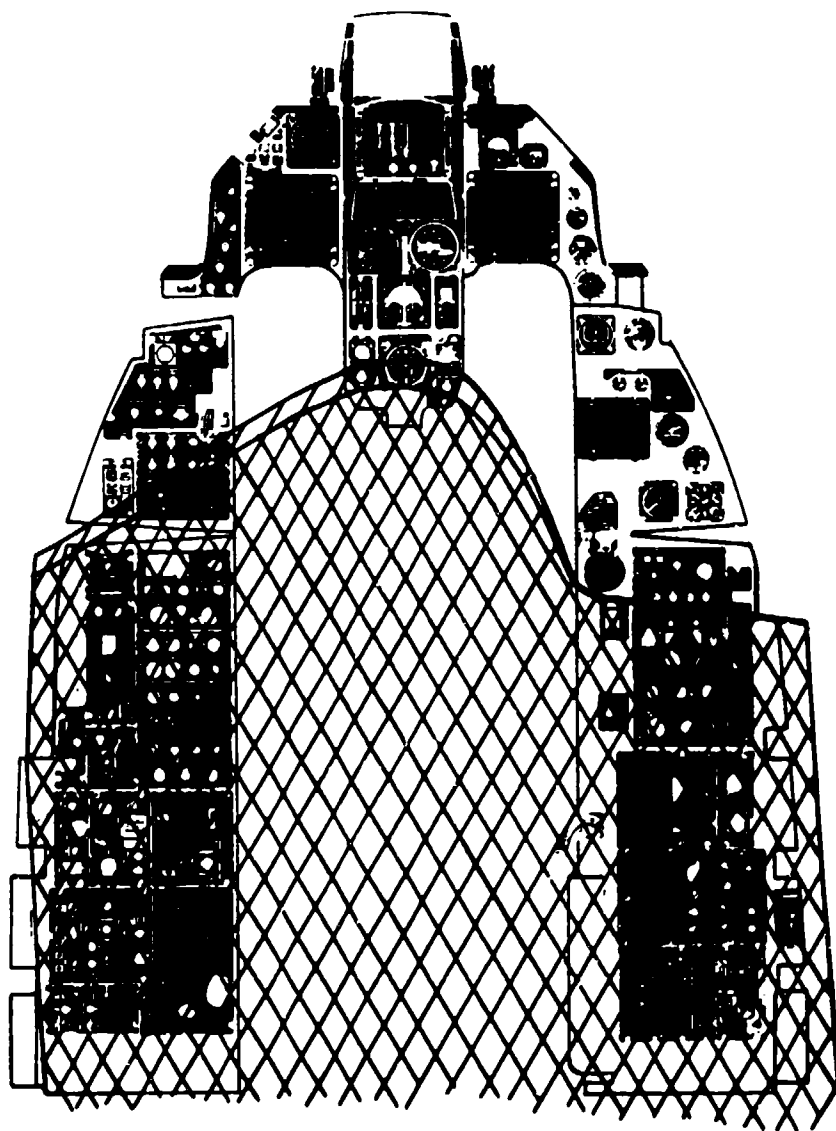
**AFT COCKPIT**

**F-16/PBG** 

**TFCS** 

Figure 7 Front Cockpit Fields of View - Pilot Two

## COCKPIT FIELD OF (FOV) WORKSHEET



**FORWARD COCKPIT**

**F-16/PBG** 

**TFCS** 

Figure 8 Rear Cockpit Fields of View - Pilot Two

noticeable in the lower abdomen, back, and arms. The blower did not distract the pilots during ground testing. All TFCS system components functioned properly in conjunction with the aircraft Class II modification in both cockpits.

### Flight Test:

Table 2 summarizes the pilots' subjective evaluations of the TFCS relative to the F-16/PBG during flight test. Responses to flight test questionnaires are presented in Appendix D.

Three AFFTC test pilots flew the TFCS in the test aircraft. Of these three, pilots A and B flew the TFCS in both the front and rear cockpits. Pilot C flew in the front cockpit only, wearing the F-16/PBG helmet and mask and the TFCS garment because he was unable to obtain a proper oxygen mask-to-face seal with the TFCS mask.

The most favored feature of the TFCS was its effective anti-g protection. Even though the flight test profiles (see Appendix C) included a number of sustained high-g points, pilots returned to base feeling only slightly fatigued. The pilots reported no tunnel vision at any test point when the assisted positive pressure breathing system was operating correctly. Pilots B and C reported experiencing tunnel vision, up to 50 percent and 20 percent respectively, during the 7 g point of the g warm-up maneuver. All pilots returned to base feeling slightly fatigued, although each asserted that he felt significantly better than he would have

without the benefit of assisted positive pressure breathing for g's.

The pilots who wore the complete TFCS ensemble found the TFCS helmet and mask provided better overall visibility relative to the F-16/PBG helmet and mask. Noise attenuation provided by the TFCS earcups and helmet, even without using the foam ear inserts for noise protection, was highly effective. During test flights, the pilots found the use of foam ear defenders unnecessary, and they were not used. Pilot A felt the TFCS helmet was more comfortable than the F-16/PBG helmet, while pilot B rated them about the same. Pilot C never wore the TFCS helmet or mask. Pilot A was the only AFFTC pilot to fly with a customized TFCS helmet and mask.

Unlike the F-16/PBG helmet, the TFCS helmet lacked an automatic mask tensioning system for tightening the mask to the face during periods of sustained high g. Although the TFCS mask was rated better overall, the lack of an automatic mask tensioning device made it impossible to achieve a balance between comfort and fit to prevent breathing gas leaks at high g's. USAF pressure breathing for g protection developmental programs should include the incorporation of an automatic oxygen mask tensioning system. (R4)

Bulkiness was the greatest drawback of the TFCS, causing annoyances in several areas, but it did not interfere with the pilot's ability to safely operate the aircraft. These areas of annoyance included restricted.

Table 2

### SUMMARY OF FLIGHT TEST RESULTS COMPARING THE TFCS WITH THE F-16/PBG

Evaluation Area	F-16/PBG Better	Equal	TFCS Better
Anti-g Protection - TFCS			X
Aircrew Performance - Cockpit operation		X	
Aircrew Comfort - Pinching and binding - Helmet and mask - Itching points - Sweating		X X	X X

torso mobility, limited reach, and control stick interference. While freedom of movement was more restrictive within the cockpit, pilot A found it was easier to look over his shoulder to "check six" with the TFCS. Pilots B and C found checking six more difficult relative to the F-16/PBG. The latter two pilots disliked the mobility restriction imposed upon them when twisting their torso during ACM/BFM. All pilots noted their reach within the cockpit was more limited when wearing the TFCS than when wearing the F-16/PBG. They found it difficult to operate some cockpit switches and controls. Pilot A, who flew with the seat raised nearly to its maximum height, noted that TFCS right leg garment inflation interfered with the flight control stick (Figures 9 and 10). When rapidly attaining and sustaining high-g's, anti-g suit inflation, in conjunction with the already ballooned wear protective trousers (due to the ventilation system), caused lateral stick deflection, resulting in an unexpected right roll. This phenomenon has occurred in the Tactical Air Force with pilots wearing the standard issue anti-g suit. Although undesirable, the pilot compensated for this deficiency once it was identified.

Similar to ground test, the point of attachment of the oxygen supply hose to the TFCS anti-g vest caused difficulties for Pilot A. The fixed oxygen hose attachment to the anti-g vest, located close to the chin, caused interference with head movements and resulted in a sharp bend in this hose which caused it to collapse under high-g. Tape had to be wrapped around his oxygen hose at this bend to prevent it from collapsing and restricting breathing gas flow to the mask under high-g.

The use of swivel connection fittings for attaching the oxygen hose to the anti-g vest and relocation of this connection to a point further from the chin would reduce the likelihood of the hose interfering with head movement and would lessen bend curvatures in the oxygen hose, thus reducing the tendency for the hose to collapse at high-g levels. The USAF pressure breathing for g protection developmental programs should make the vertical oxygen hose anti-g vest

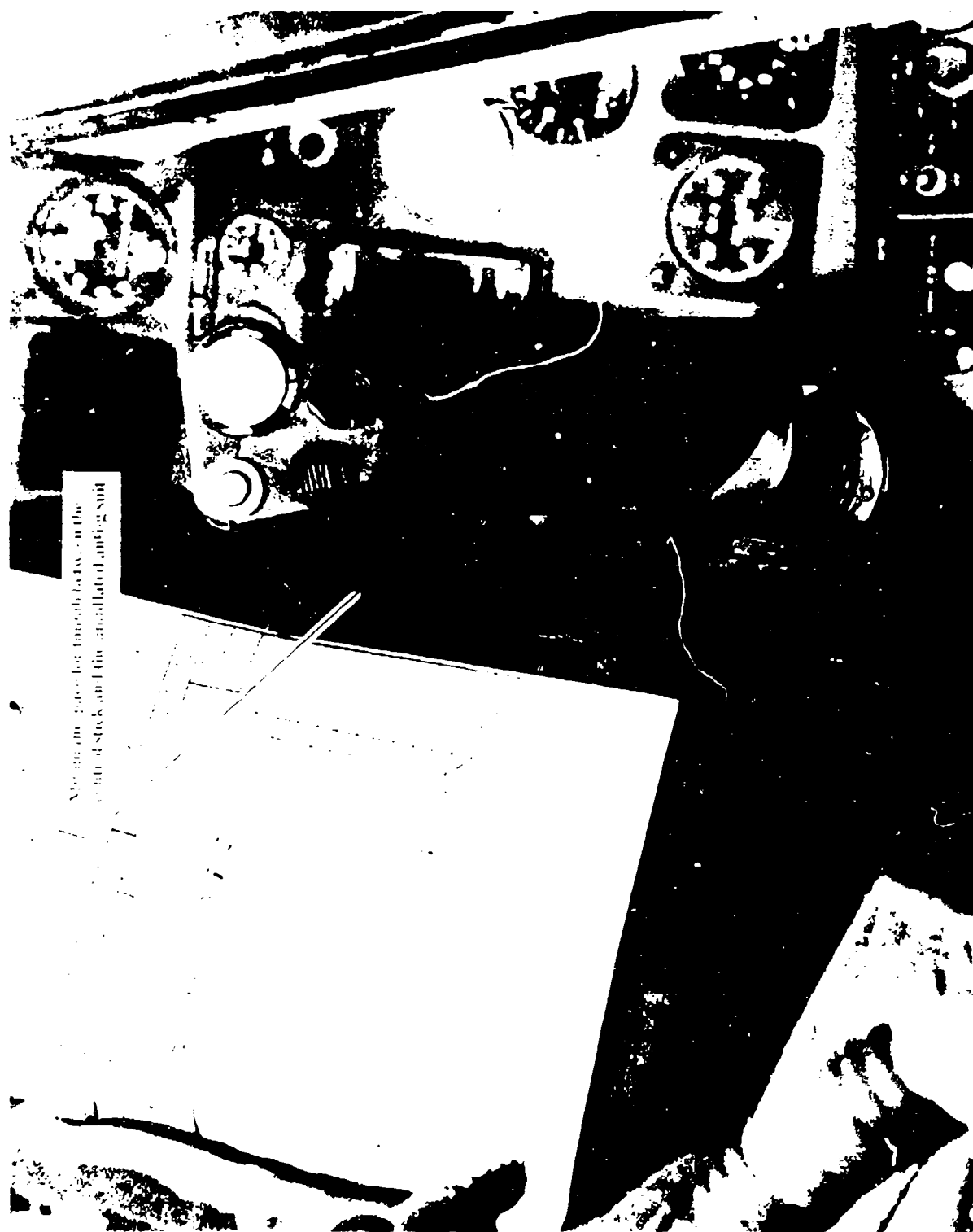
attachment a swivel type connection located away from the pilot's chin. (P3)

The flexible senselines in both cockpits functioned correctly after the Class II modification. During the second flight, the front cockpit pilot noticed less pressure in his PBG mask relative to his previous PBG experience. Aircraft vibration and/or g forces had caused the senseline in the front cockpit to become pinched under the map case. To eliminate possible constriction and loss of signal, future designs should avoid the use of a flexible pneumatic senseline between the g-valve and oxygen regulator. (R5)

Testing showed that pilot comfort in the cockpit was dependent upon suit fit. While wearing the TFCS, the pilots noted proper arrangement of their underwear and flight suit components prior to ingressing the cockpit was necessary for flight comfort. The TFCS, particularly its anti-g suit component, covered more body area with inflatable bladders. The importance of fit was reflected in the increased bladder coverage.

The air ventilation system of the TFCS was effective in cooling the pilots, even at lower flow settings. Although the amount of air delivered to the suit by the blower could be adjusted during flight, most pilots left the control valve in the fully open position. Regardless of the flow setting, pilot observation indicated that ventilation was not uniformly distributed to all parts of the body. This was not objectionable. Most of the sweating in the TFCS occurred during ground operations prior to closing the canopy. The significance of this result showed that, relative to heat stress, a full coverage anti-g/immersion suit with PBG capability could be as comfortable as the standard anti-g suit. The blower itself did not distract the pilots in-flight.

Pilots A and B reported that they would use the TFCS on every high-g or ACM/BFM sortie. Pilot C preferred his F-16/PBG over the TFCS, because it was not as bulky and was less restrictive of movement while in or out of the cockpit.



View from the cockpit looking forward in the  
direction of flight.



Figure 10 Inflated TICS

## CONCLUSIONS AND RECOMMENDATIONS

The overall objective was to subjectively evaluate the Tactical Flight Combat Suit (TFCS) in a sustained high-g operational environment in comparison to the F-16/PBG. This objective was fully met by this test.

High-g test flight profiles showed the TFCS was more effective in providing pilots enhanced g protection than the F-16/PBG. The TFCS was a significant improvement for enhancing anti-g protection relative to the standard issue anti-g suit.

***1. The USAF should develop a full coverage anti-g suit for pilots flying in high performance aircraft. (Page 5)***

A significant finding of this test was that anti-g and anti-exposure suit features may be successfully incorporated into one operationally effective flight ensemble.

***2. The USAF should pursue the development of a flight ensemble that combines anti-g and anti-exposure protection for use by fighter pilots flying in conditions that currently require the use of the CW-21/P anti-exposure suit. (Page 6)***

Putting on the TFCS for the first time was difficult due to the unfamiliarity and bulkiness of the ensemble. The TFCS was complex and more time was required to don all its components. However, by the end of flight test, pilots were easily donning and doffing the TFCS. Familiarity with the TFCS in the cockpit also improved as the test progressed. Still, the fixed point of attachment of the oxygen supply hose to the g-vest interfered with cockpit mobility and head movement because it was located too close to the pilot's chin. It also caused a sharp bend in the oxygen hose, causing it to collapse under high g's. The F-16/PBG had a swivel connection which allowed freer oxygen hose and head movement, and was located further away

from the chin. A swiveling attachment located a little further away from the chin would reduce the likelihood of the hose interfering with head movement or collapsing during high-g points.

***3. The USAF pressure breathing for g protection developmental programs should make the vertical oxygen hose anti-g vest attachment a swivel type connection located away from the pilot's chin. (Pages 7 and 16)***

There were significant differences between the TFCS and F-16/PBG masks and helmets. The TFCS mask itself was rated better overall. The TFCS mask and helmet provided pilots with an increased field of view, highly effective noise attenuation, and both clear and tinted visors. Unlike the F-16/PBG helmet, the TFCS helmet lacked an automatic mask tensioning system for tightening the mask to the face during periods of high g. This required the pilots to keep the mask uncomfortably tight all the time in order to prevent breathing gas leaks at high g.

***4. The USAF pressure breathing for g protection developmental programs should include the incorporation of an automatic oxygen mask tensioning system. (Page 15)***

Aircraft vibration and/or g forces caused the senseline running from the g-valve to the oxygen regulator in the front cockpit to work under the map case, pinching the senseline between it and the aircraft. Constriction of this senseline caused a loss of the pneumatic signal being sent to the oxygen regulator which then failed to provide the pilot with proper PBG protection.

***5. To eliminate possible constriction and loss of signal, future designs should avoid the use of a flexible pneumatic senseline between the g-valve and oxygen regulator. (Page 16)***

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**APPENDIX A**  
**TFCS AND F-16/PBG SYSTEMS DESCRIPTION**

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# TFCS AND F-16/PBG SYSTEM DESCRIPTIONS

## FUNCTIONAL OVERVIEW OF EACH SYSTEM

The modular Tactical Flight Combat Suit (TFCS) included a lightweight helmet, low profile oxygen mask, combined ventilated anti-g and immersion suit, wear protective trousers, and a specialized anti-g/survival vest. The F-16/PBG included a one-piece flight suit, low profile oxygen mask, and a unique helmet. The F-16/PBG featured the same anti-g suit bladder coverage as the standard CSU-13B/P anti-g suit worn by USAF pilots flying aircraft equipped with a g-valve. Inflatable chest bladders were incorporated into the upper portion of each ensemble. When at greater than 5 g's, the oxygen regulator supplied assisted positive pressure breathing gas to the mask, inflating the air bladders covering the chest for balanced chest counterpressure. Both systems provided protection to aircrews from sustained high-g.

## COMPONENTS

Figure A1 shows a photograph of the TFCS and F-16/PBG helmets and masks. This comparison of the helmet/mask assemblies illustrates differences in the two systems. The TFCS helmet was shorter and wider than the F-16/PBG. The TFCS assembly had standard offset bayonet connectors to attach the oxygen mask to the helmet while the F-16/PBG assembly did not. Also the mask dropped from the right side (left side hinge) with the TFCS assembly, and the intercom cord was on the left, while the mask dropped from the left side (right side hinge) with the F-16/PBG assembly, and the intercom cord was on the right. Note the single visor control knob on the F-16/PBG (visor movement was accomplished on the left) helmet while the TFCS helmet had symmetrical visor control knobs which moved two different visors.

An oblique view of each helmet is shown in Figure A2. The facial openings, visor adjusting knobs, and the earcup designs were different for the two helmets. Also the TFCS helmet lacked a chin strap but had both clear and tinted visors.

A bottom view (Figure A3) shows that the TFCS helmet was slightly shorter than the F-16/PBG helmet in the front-to-back plane. Also the lower front margin of the TFCS curved inward, providing a snug fit at the

mandibular angle of the lower jaw. An automatic mask tensioning bladder was in the back of the F-16/PBG helmet.

Figures A4 and A5 show front views of a test pilot wearing the TFCS and F-16/PBG helmets and masks, respectively. Mask profiles, microphone and intercom attachments, and oxygen hose routings were different for the two masks. The hose attaching to the left side of the TFCS mask was used during testing to measure breathing gas pressures in the mask.

Figures A6 through A9 show the right and left sides of the two helmet/mask assemblies. The difference in the frontal projection of the two masks is illustrated in Figure A10. The F-16/PBG mask is deeper and extends further from the face.

Flight suits were significantly different. Figure A11 shows a test pilot wearing the F-16/PBG. This unique ensemble, designed to provide pilots protection from sustained high-g, had laces in the legs and torso areas for a snug fit. The suit had the standard anti-g suit bladder coverage to the lower body and the hose which connected into the g-valve located in the cockpit. The oxygen hose connected to the CRU-60/P which was located on the parachute harness. It had a swivel attachment to the anti-g vest portion of the ensemble that covered the torso enroute to the mask. The anti-g suit functioned independently of the anti-g vest and mask below 5 g's. At 5 g's and greater, the g-valve sent a proportionate pneumatic signal to activate the oxygen regulator to proportionately increase breathing gas output to the anti-g vest, automatic mask tensioning bladder, and the mask.

The Tactical Flight Combat Suit (TFCS) was a modular flight suit designed to provide pilots protection from sustained high-g's, cold water immersion, and heat stress.

Pilots wore underwear to protect their skin from chaffing, and to wick perspiration away from the skin. The anti-g/immersion suit component of the TFCS was donned first. This component was donned while in a seated position (Figure A12). It had anti-g bladders incorporated into the impervious layer of the

F-16/PBG

TFCS

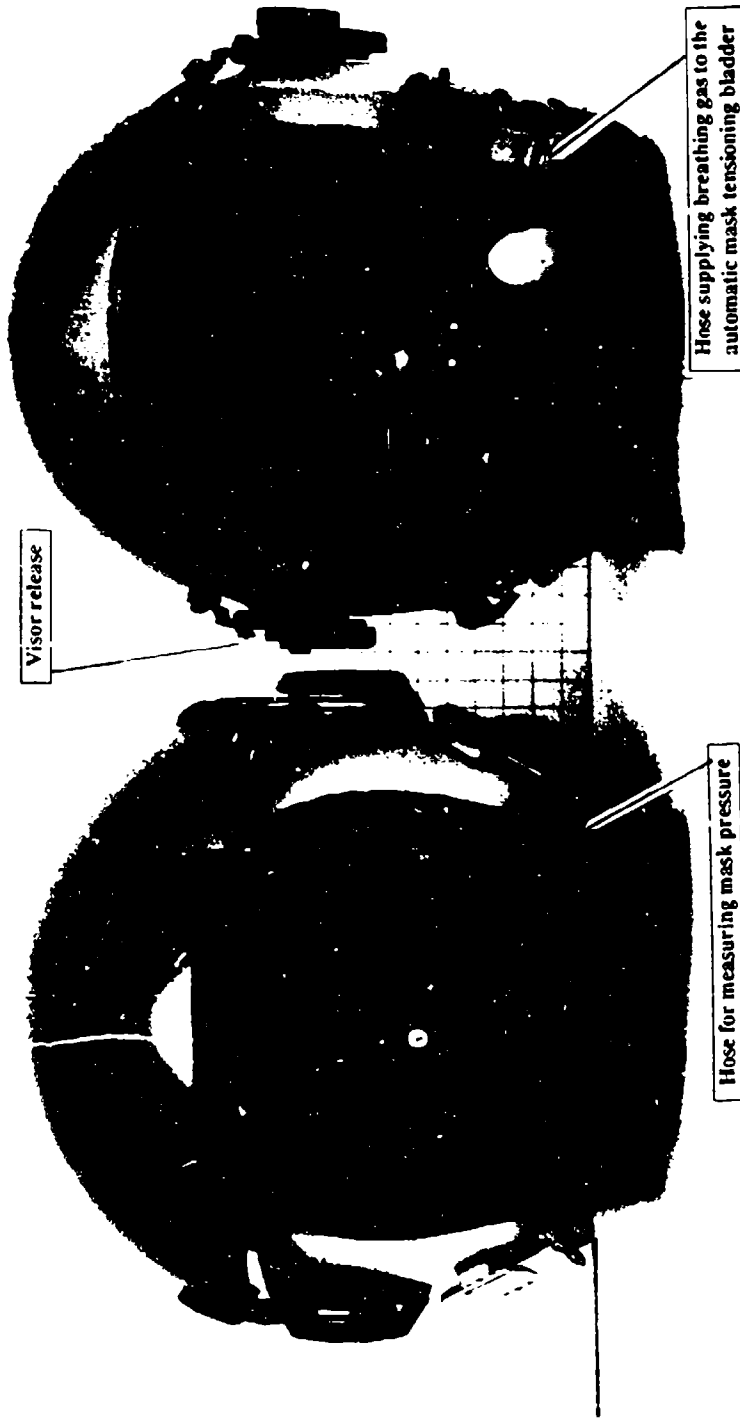


Figure A1 Front View of TFCS and F-16/PBG Helmet/Masks

TFCs

F-16/PBG

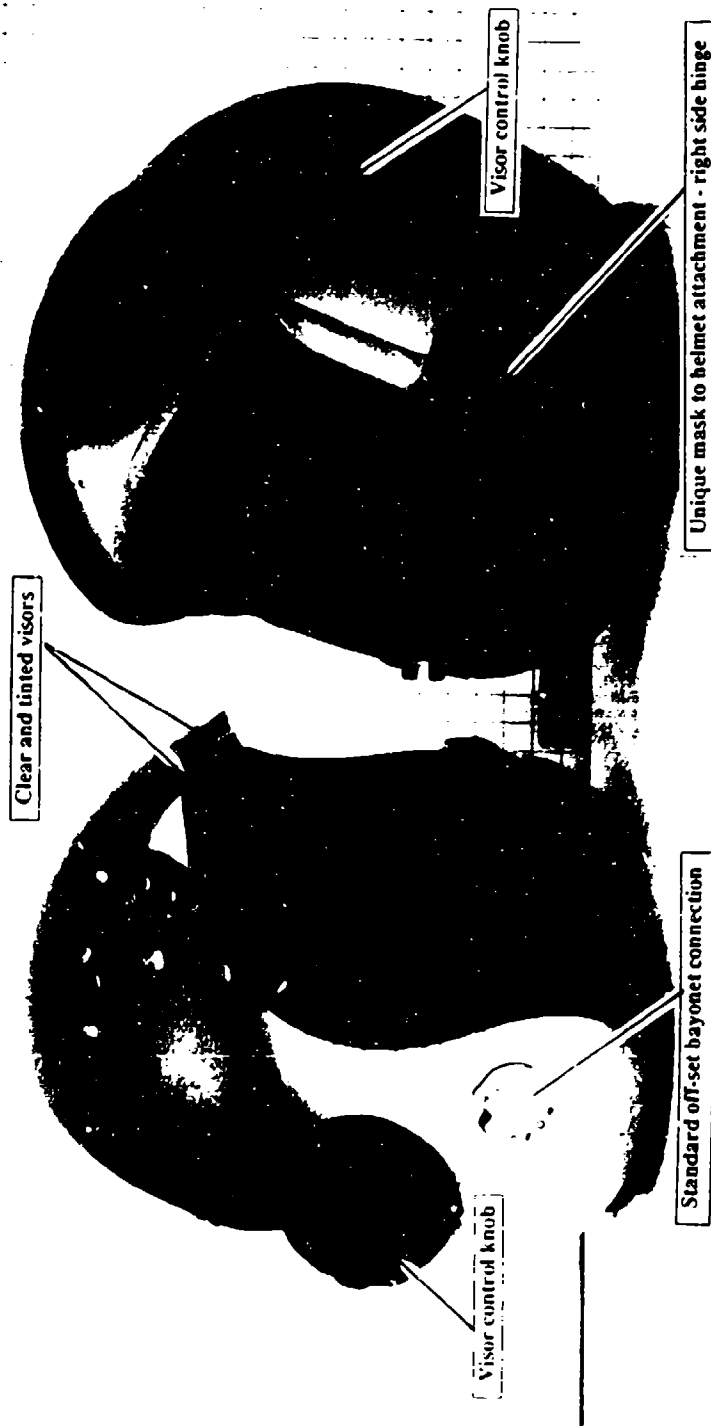


Figure A2 Oblique View of TFCs and F-16/PBG Helmets

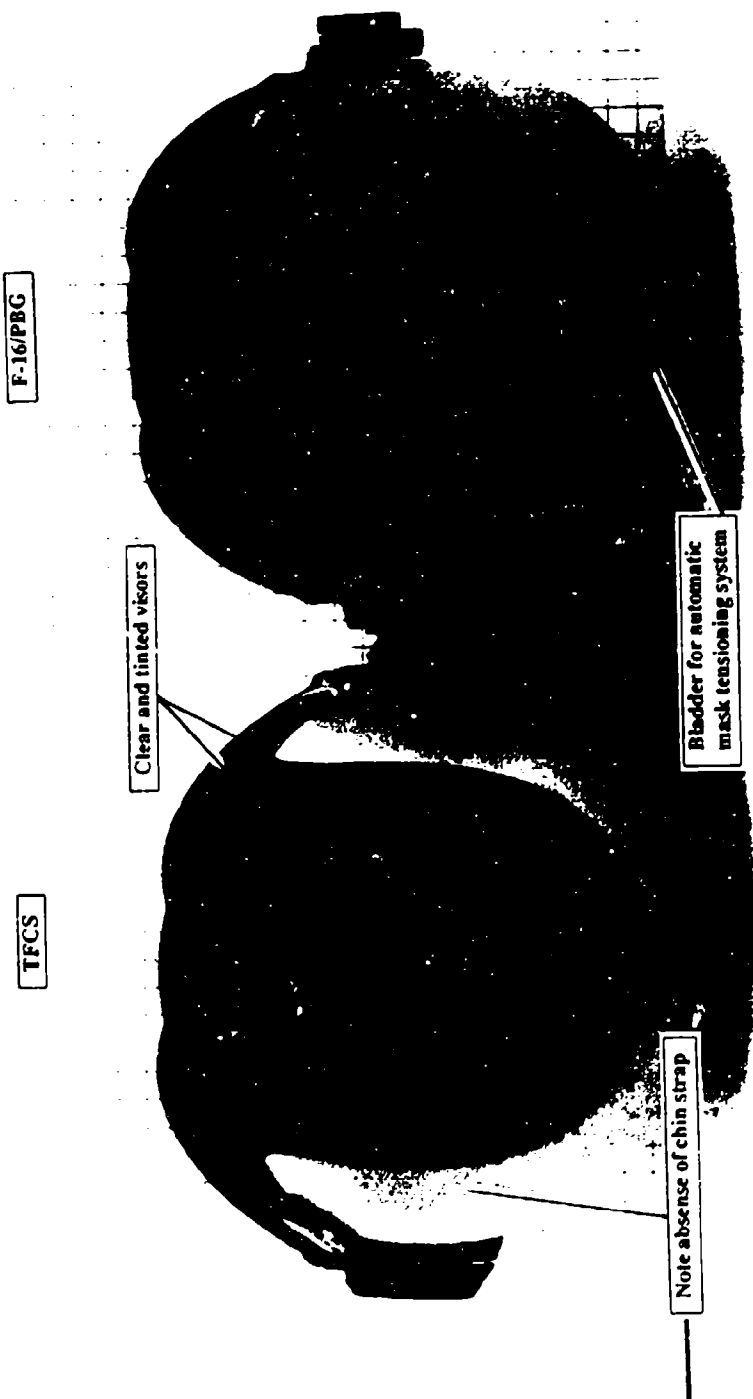


Figure A3 Bottom View of TFCS and F-16/PBG Helmets



Figure A4 TFC Helmet/Mask Assembly - Front

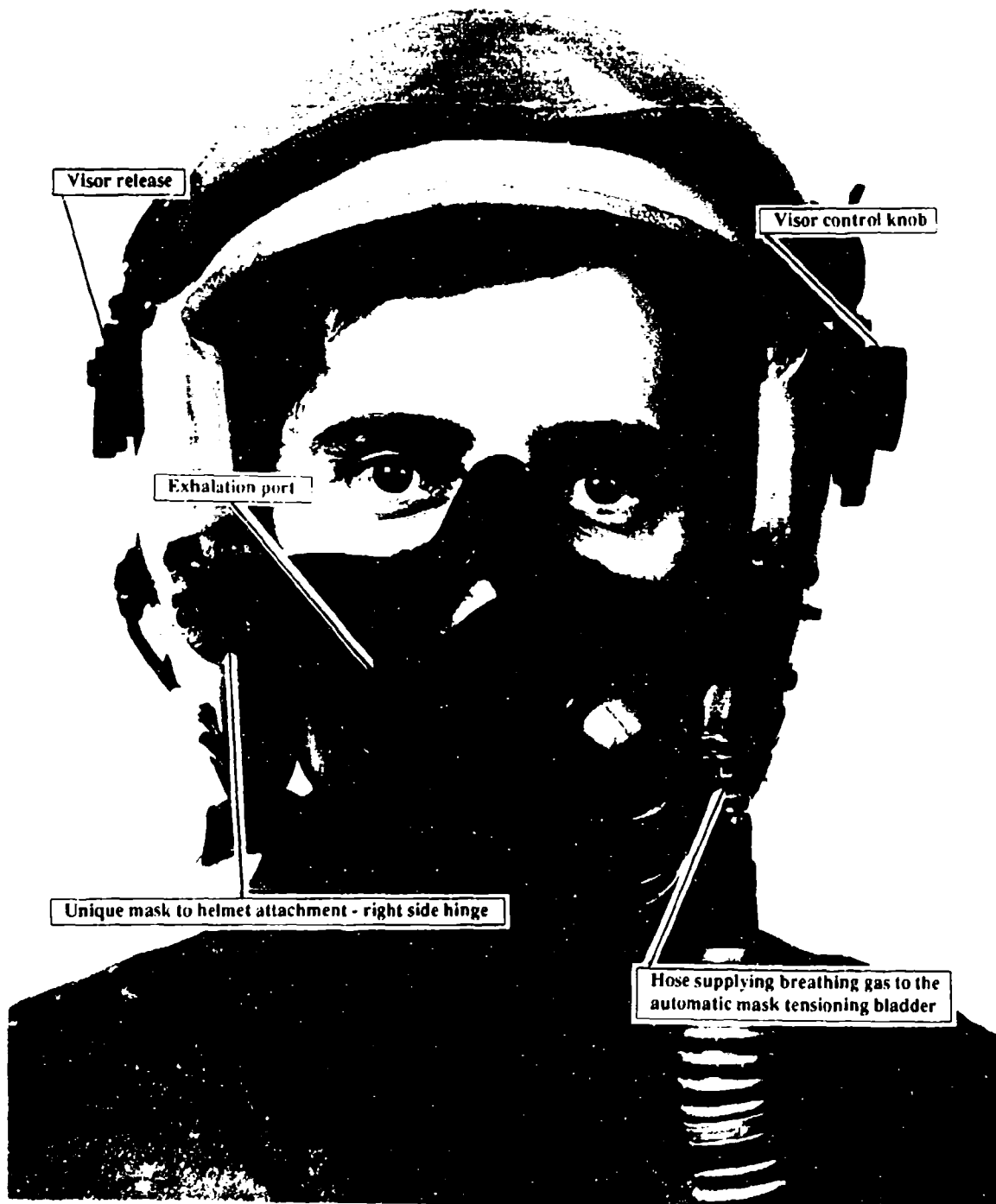


Figure A5 F-16/PBG Helmet/Mask Assembly - Front



Figure A6 TFC Helmet/Mask Assembly - Right View

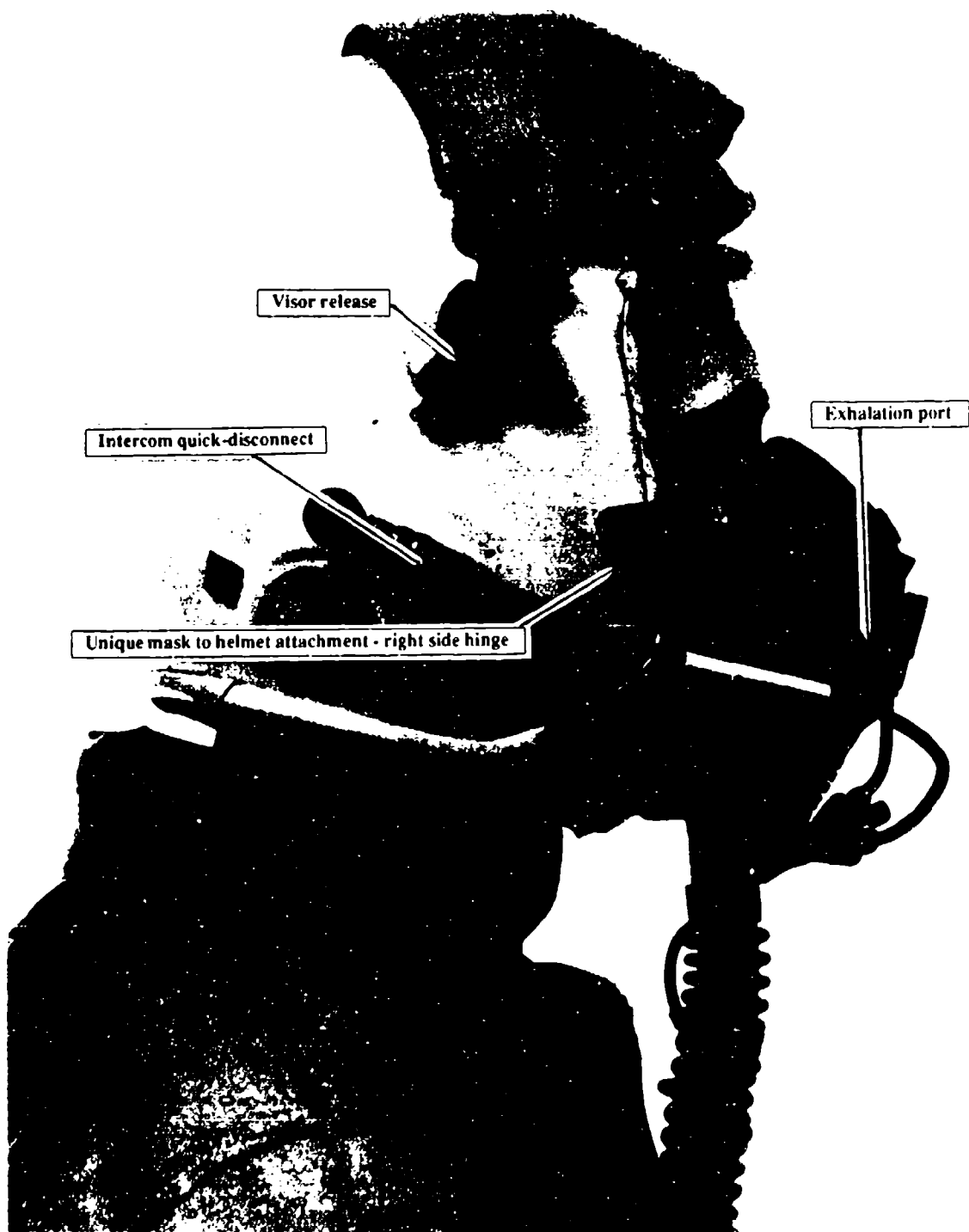


Figure A/ F-16/PBG Helmet/Mask Assembly - Right View



Figure A8 TICS Helmet/Mask Assembly - Left View



Figure A9 F-16/PRG Helmet/Mask Assembly - Left View

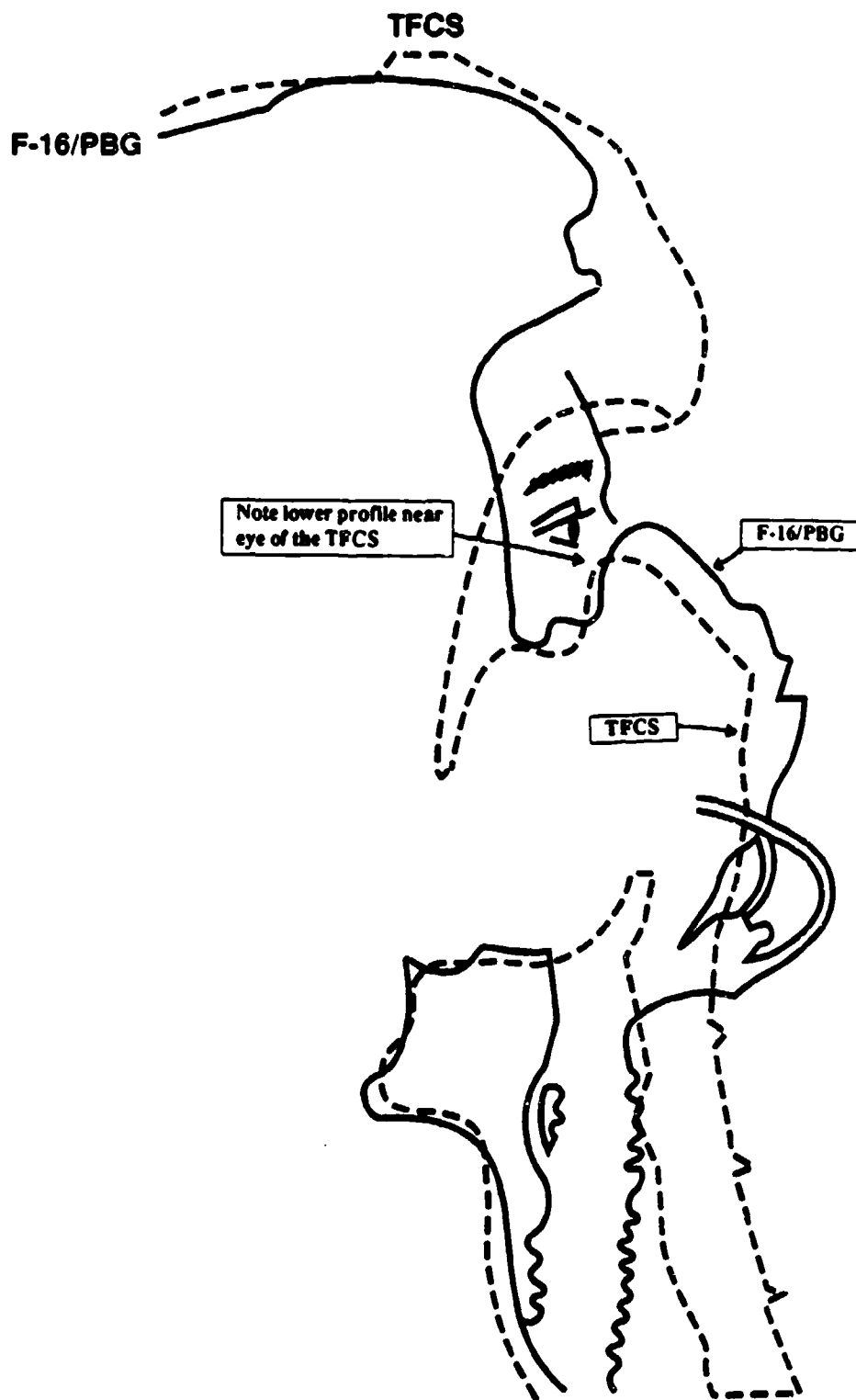


Figure A10 Overlay of TFCS and F-16/PBG Masks

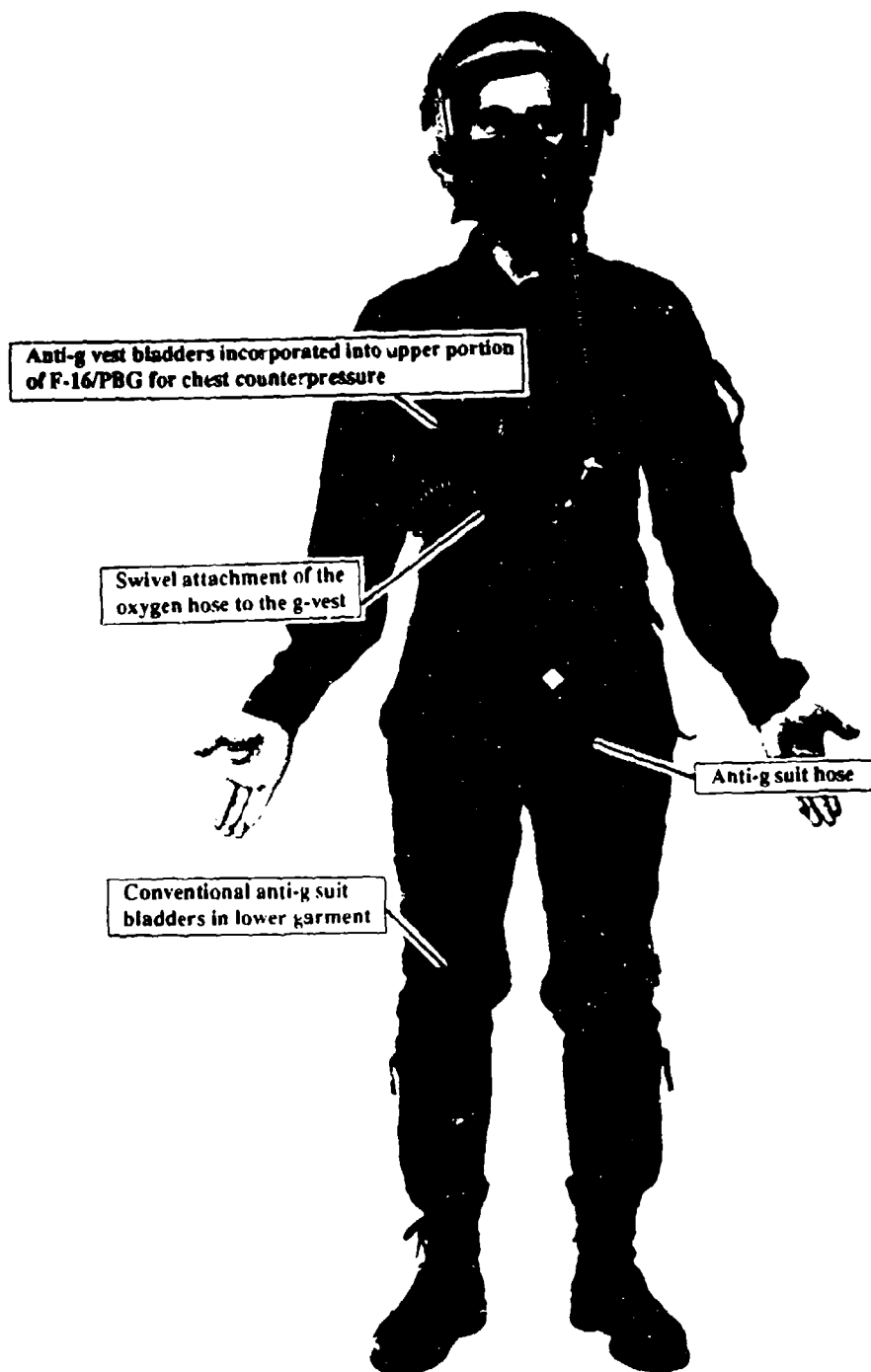


Figure A11 F-16/PBG - Front

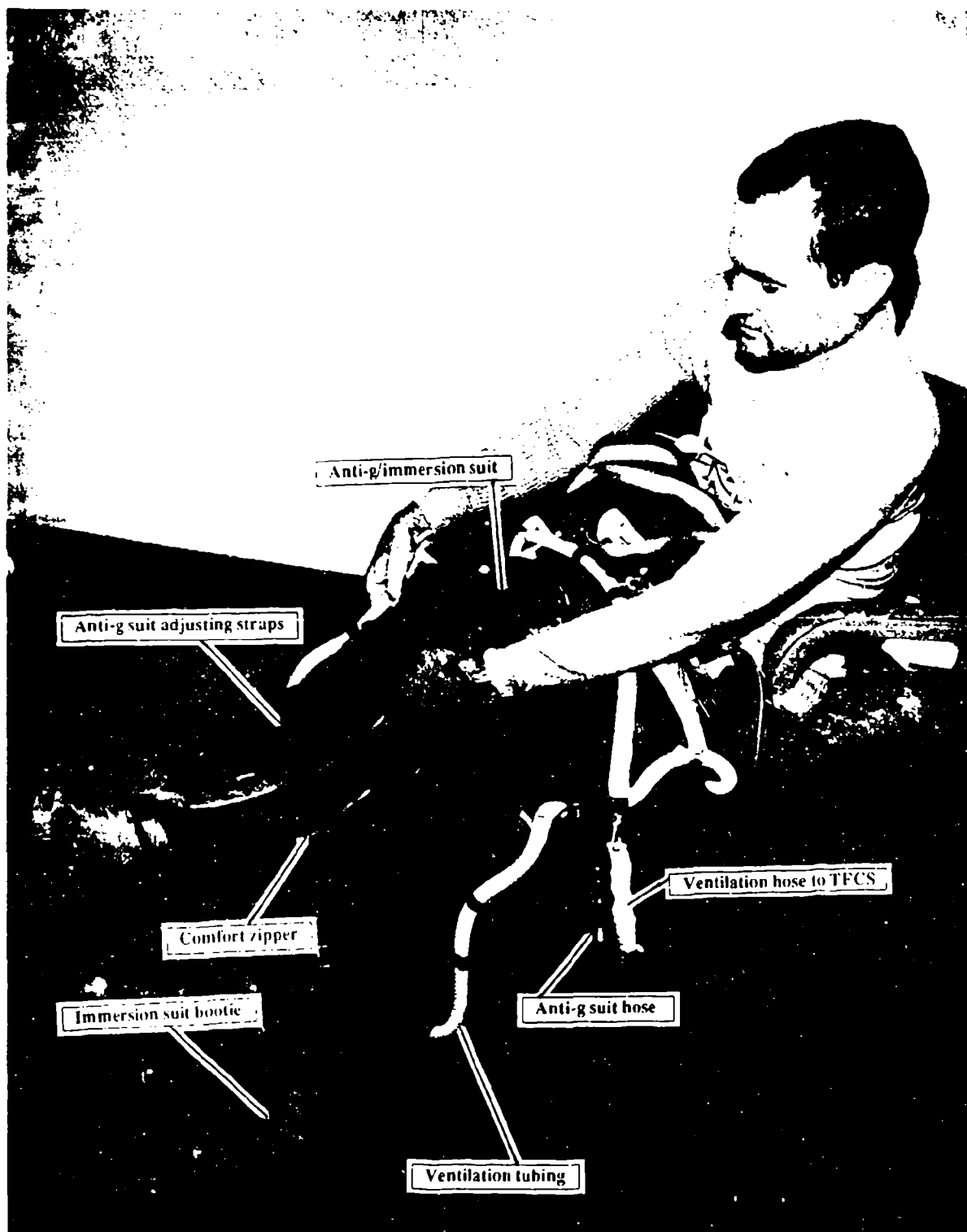


Figure A12 Pilot Donning Anti-g/Immersion Suit of TFCS

anti-exposure suit. The anti-g suit bladder coverage was greater than that of the standard anti-g suit (Figure A13). The booties of the anti-exposure suit did not contain anti-g bladders. Numerous adjustable straps were located down the legs for an effective fit to maximize anti-g protection. The plastic tubing along the lateral length of the suit provided ventilated air to the legs. Comfort zippers, opened when donning the suit and flight boots, were located along the medial length of each leg. These zippers were closed prior to donning the wear protective trousers. To don the upper portion of the anti-exposure suit, the pilot placed his head through a rubberized hole in the central flap of the suit and zipped it closed (Figure A14). Plastic ventilation tubes were located along the sides of the upper portion of the anti-exposure suit for cooling the torso.

After securing the anti-g/exposure suit, the pilot donned the wear protective trousers (WPT). Zippers were located along the inside length so pilots could don

this garment while wearing flight boots. The WPT protected the ventilation tubes and reduced the risk of snagging the anti-g suit adjustable straps (Figure A14). The anti-g suit connecting hose and the ventilation hose were routed through a slit in the left side of the WPT. Figure A15 shows the back of the WPT fitted on the pilot.

Next the pilot donned the anti-g/survival vest which contained air bladders to provide chest counterpressure during periods of positive pressure breathing. It was important that the anti-g vest fit snugly to the pilot. To accomplish this, the anti-g vest had adjustable laces on each side (Figure A16). The design of these laces permitted rapid alterations when the vest was worn by more than one pilot or over a flight jacket. A front view of the ensemble, with the pilot wearing the helmet and mask, is shown in Figure A17. This photograph shows the pilot attached to the portable blower used to ventilate the TFCS on the ground prior to cockpit ingress.

# FULL COVERAGE ANTI-G SUIT BLADDER

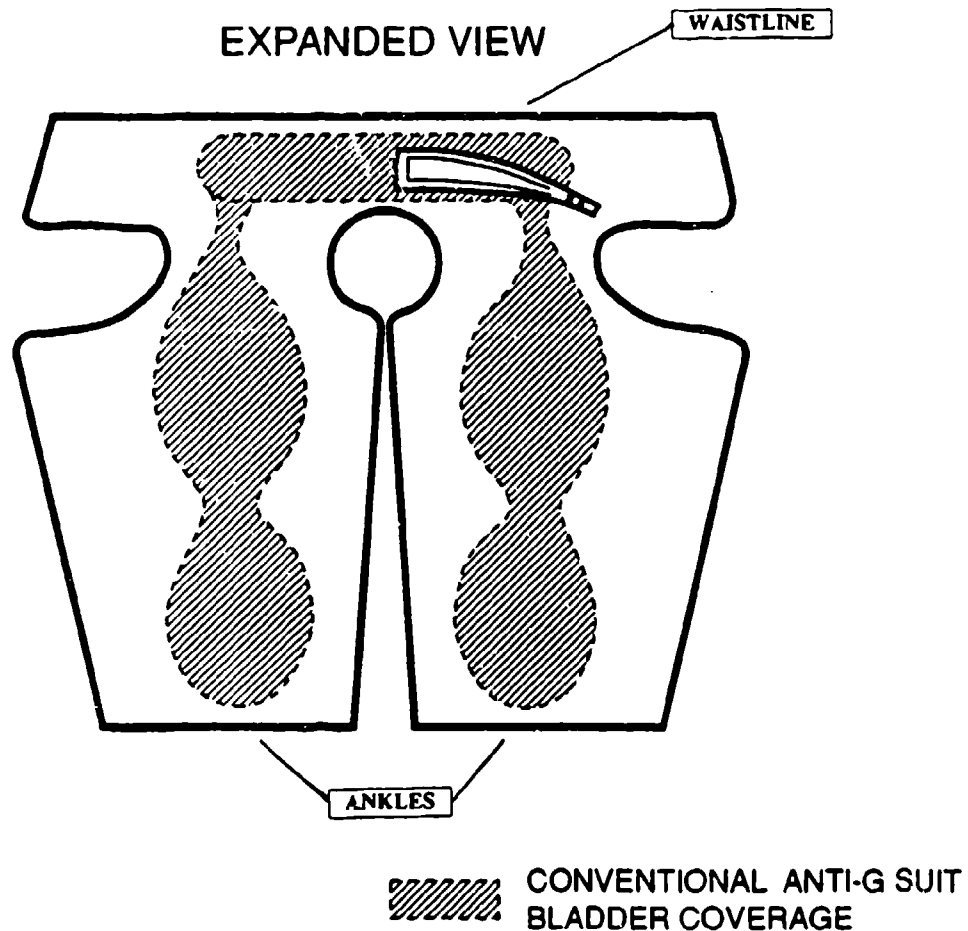


Figure A13 TFCS Versus Conventional Anti-g Suit Bladder Coverage

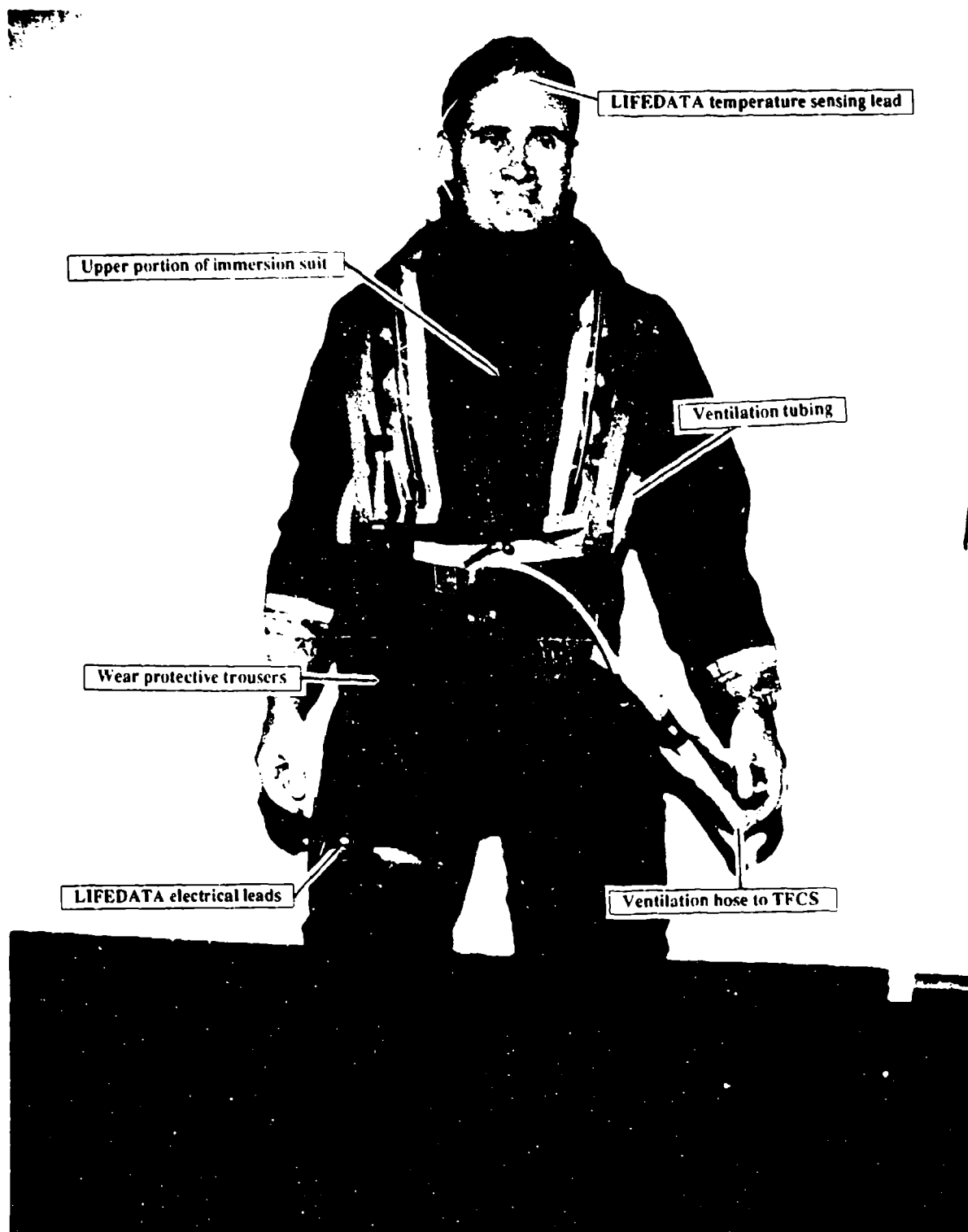


Figure A14 TFCS Anti-g/Immersion Suit and WPT - Front

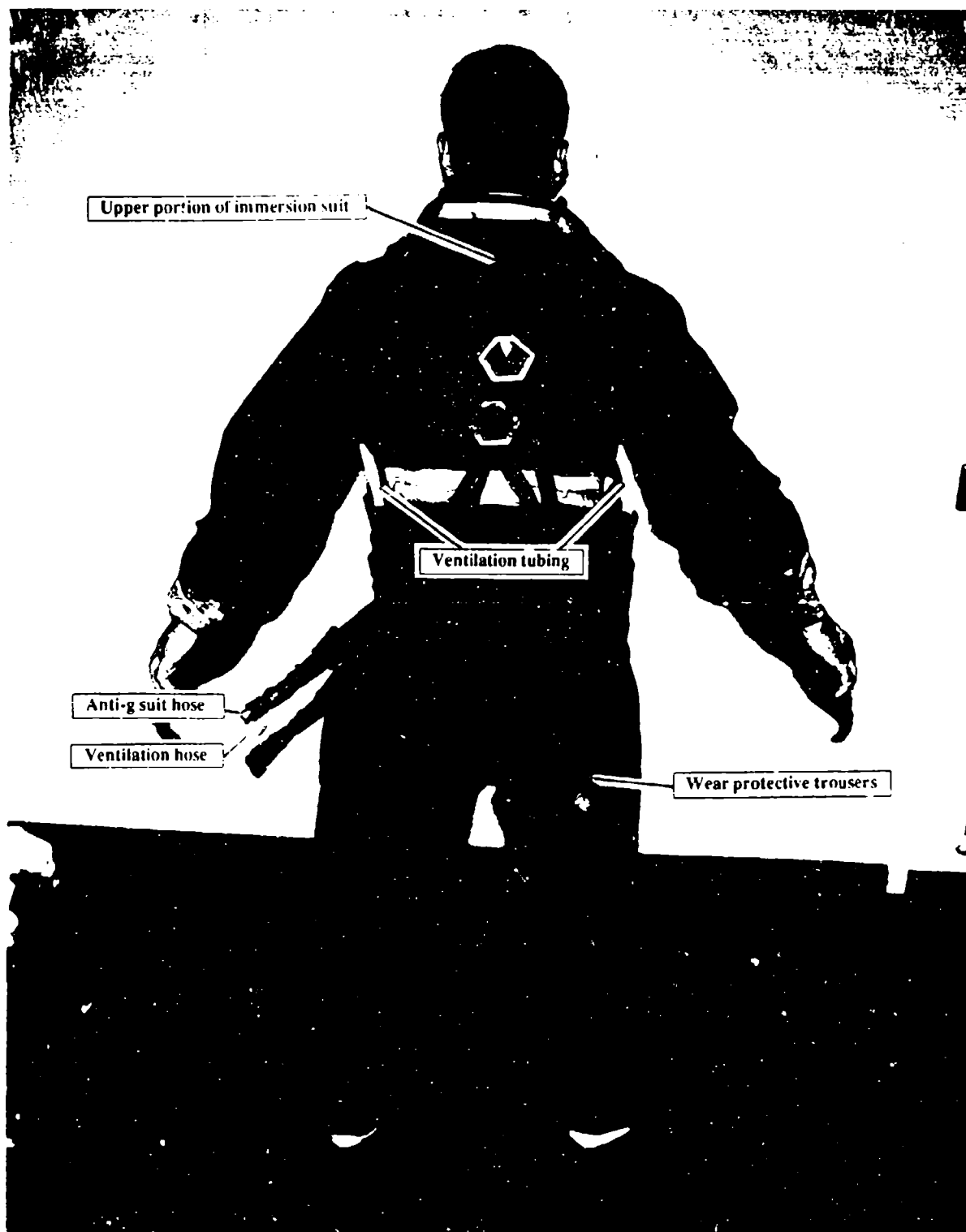


Figure A15 TFC's Anti-g/Immersion Suit and WPT - Back

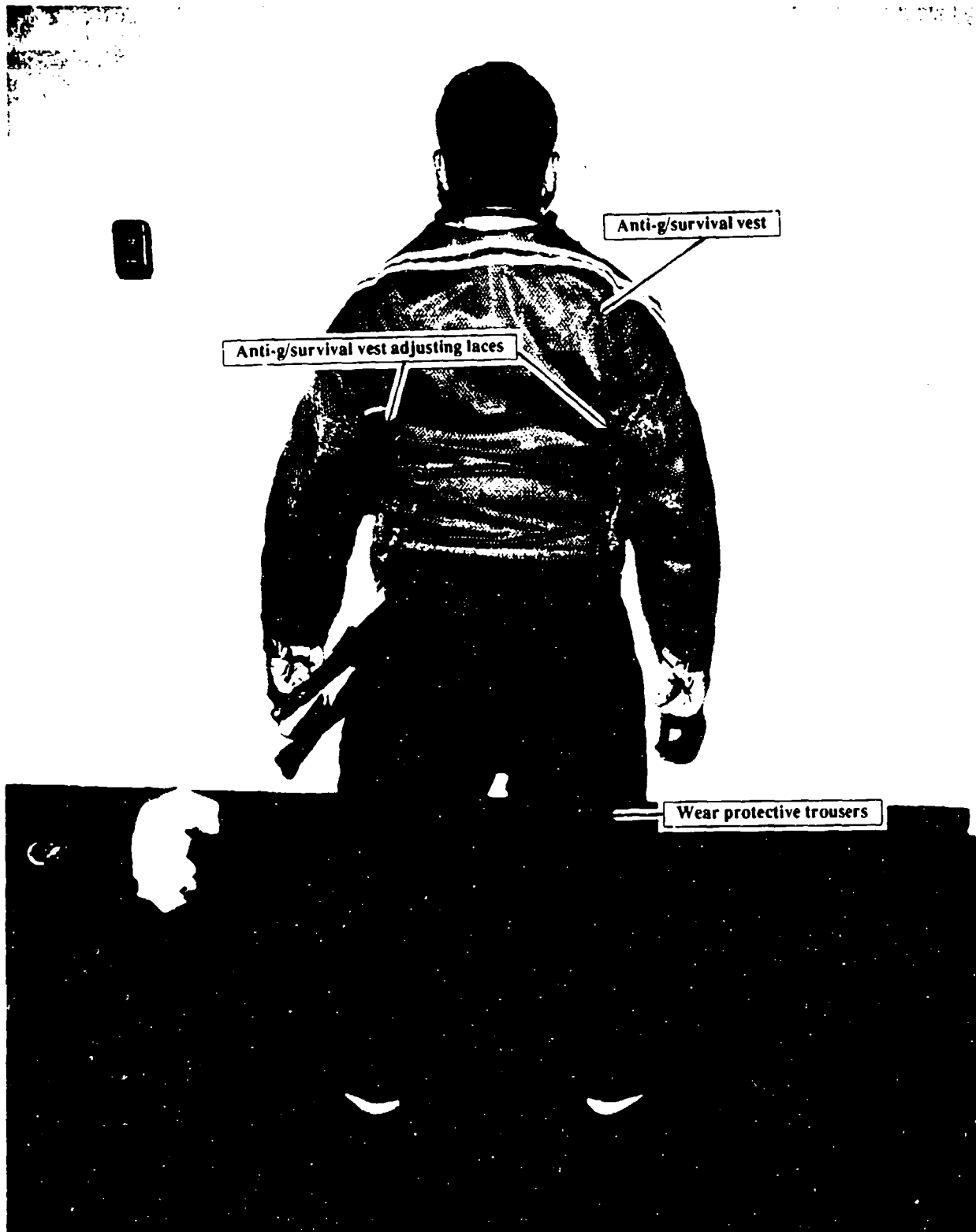


Figure A16 TFCS Suit Components - Back

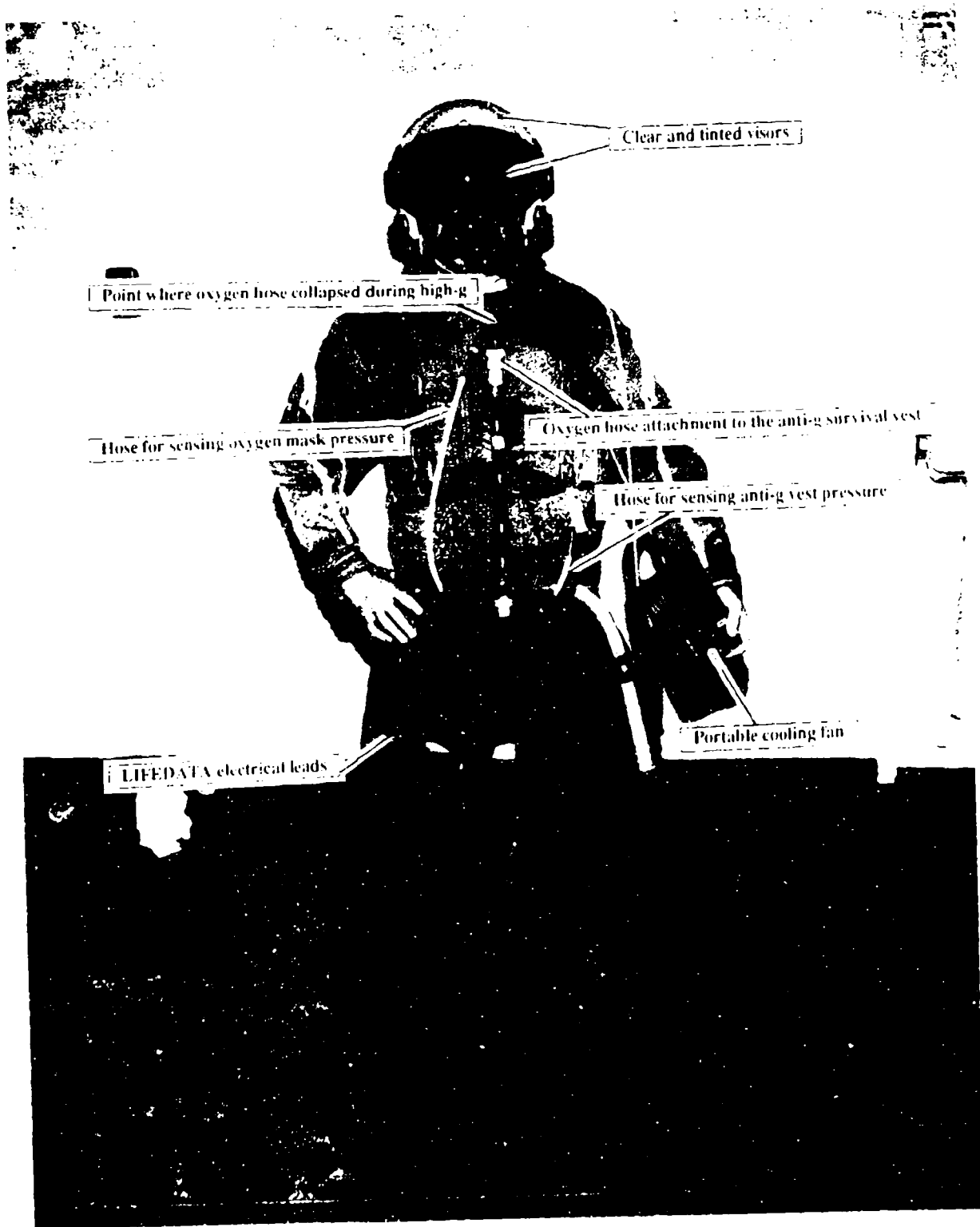


Figure 1. AF7 Tactical Flight Combat Suit with Ventilator

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**APPENDIX B**  
**AIRCRAFT CLASS II MODIFICATIONS**

## AIRCRAFT CLASS II MODIFICATIONS

Table B1 lists the components included in the aircraft Class II modification.

Aircraft F-16B, S/N 31-0816, was modified to support this test. Both cockpits were modified to accommodate a Clifton Precision modified CRU-73/A oxygen regulator. The regulators were modified by the manufacturer with internal relief valves for venting excessive back-flow pressures. As a result of this internal modification, the integrity of these regulators was not testable by standard Technical Order procedures. Attached to the back of each regulator was an electrical solenoid. The solenoid was opened or closed by a PBG switch located on the cockpit panel (Figure B1). With the PBG switch in the "off" position, the oxygen regulator would not deliver breathing gas at pressures greater than the standard CRU-73/A oxygen regulator. Figure B1 also shows the mechanical PBG control valve designed into the Class II modification package as a safety feature. When this mechanical valve was opened (counter clockwise rotation), air was allowed to flow through a senseline connecting the g-valve to the oxygen regulator. Closing the valve stopped the flow of air.

The senseline mentioned above was a flexible tube installed between the g-valve and the oxygen regulator for the purpose of sending a pneumatic signal from the g-valve to the oxygen regulator (Figure B2). Pressure transducers were located in-line, one near the g-valve, and one near the oxygen regulator. These transducers

sensed pressure levels, first in the g-valve, and then in the oxygen regulator. With the proper pressure signal from the g-valve (based on g input), the oxygen regulator would increase its breathing gas pressure output to the pilot at pressure levels greater than normal but less than 60 mm Hg. Because of this pressure sensing system between the g-valve and the oxygen regulator, a 3/8 inch diameter hole was drilled into the check valve located in the anti-g suit hose connectors. With this hole in the check valve, the flow of air was unrestricted through the connector.

A ventilation system was installed in each cockpit to provide cooling air to pilots wearing the TFCS. This system included a blower motor controlled with an electrical "on/off" switch and connecting hose. The blower (fan) was located near the anti-g valve (Figures B3 and B4) so that the anti-g hose and ventilator hose would be bound together in the cockpits. The ventilator hose attached to the TFCS via a siip connector. This connector contained a sliding control valve which permitted the pilot to regulate the flow of cooling air into the suit.

Fleisch flow meters were installed under the right side panels in-line between the oxygen regulator and the pilot (Reference 8). Figure B5 shows the flow meter during installation. The flow meters measured and monitored the rate and depth of the pilot's breathing throughout the flight. This signal was recorded on the aircraft analog data tape.

Table B1

### AIRCRAFT CLASS II MODIFICATION COMPONENTS

Component	Front Cockpit	Rear Cockpit
Modified oxygen regulator	X	X
Electrical PBG switch	X	X
Mechanical PBG valve	X	X
g-valve pressure transducer	X	X
O2 regulator pressure transducer	X	X
Flexible senseline	X	X
Modified g-valve connector	X	X
Ventilator motor and hose	X	X
Fleisch flow meter	X	X
Flow meter pressure transducer	X	X
LIFEDATA circuit board box		X
LIFEDATA recorder		X

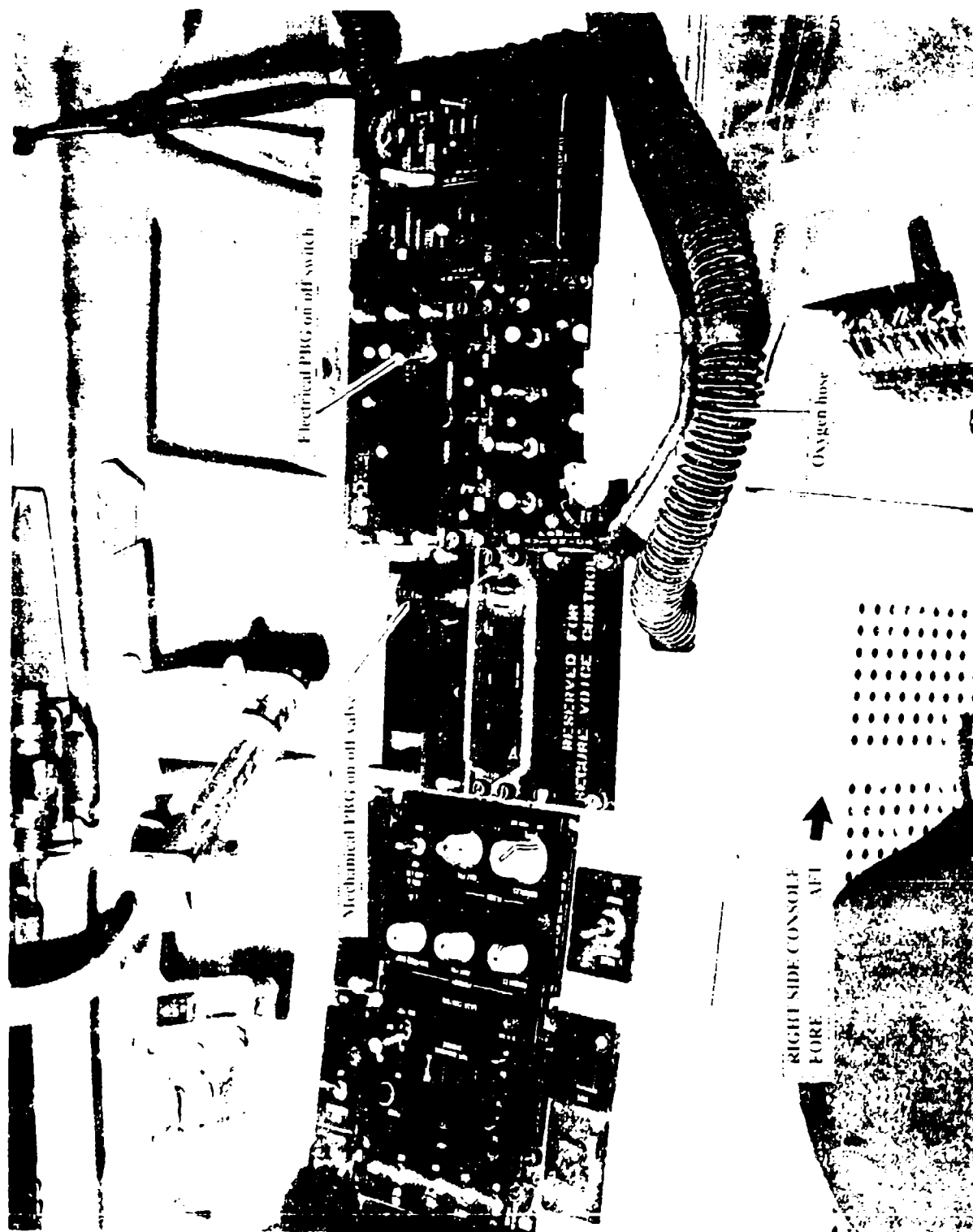


Figure B1 Front Cockpit Location of the PRG Electrical "On/Off" Switch and Mechanical Control Valve



Figure B2 Flexible Senseline in Cockpit

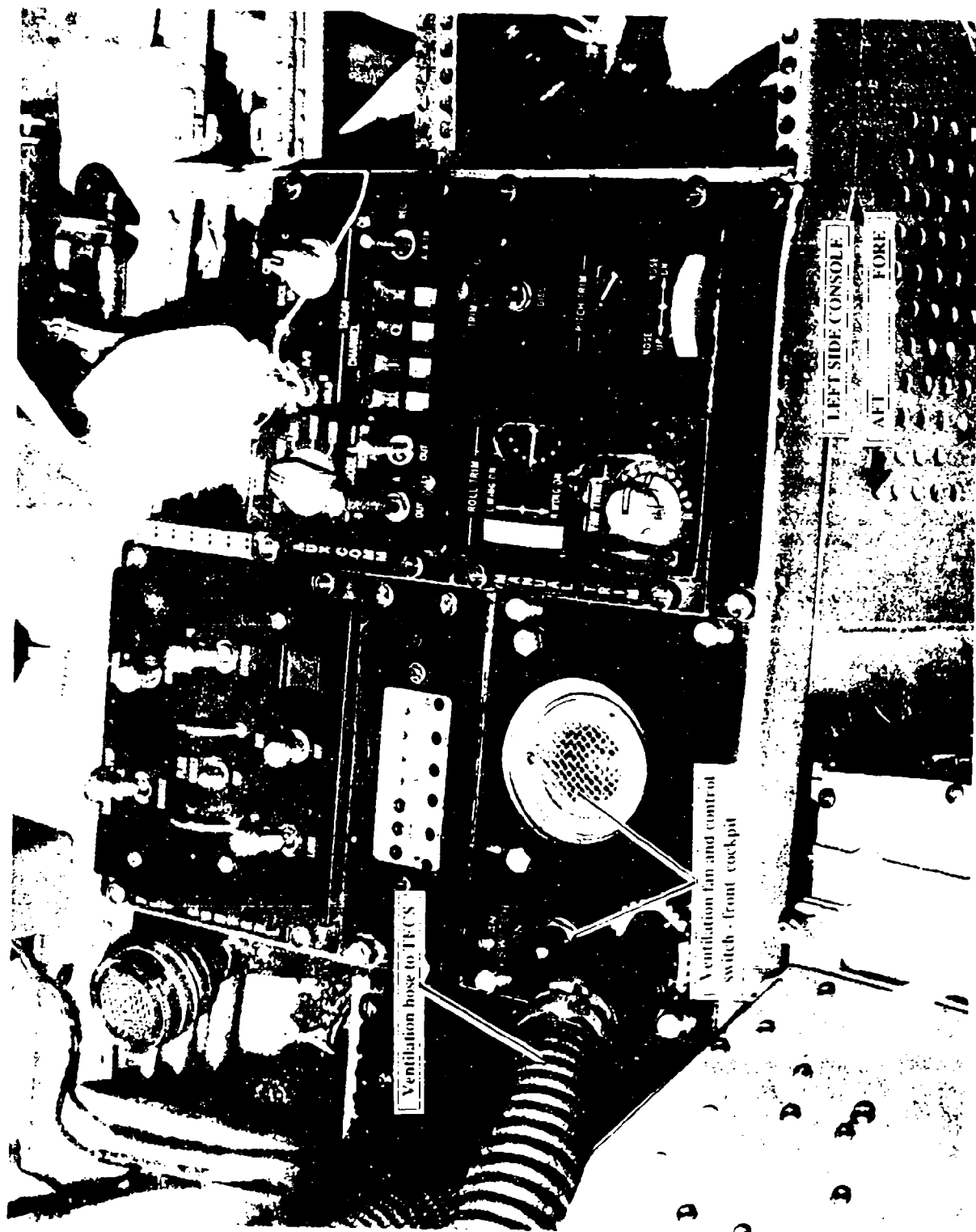


Figure B3 Ventilation Fan and Hose in Front Cockpit



Figure B4 - Ventilator Fan and Hose in Rear Cockpit



RIGHT SIDE CONSOLE  
FLOOR

LIFEDATA, the Swedish stand-alone physiological data collection system, was installed in the rear cockpit only. This system consisted of a box of computer boards and integrated circuits (Figure B6) mounted in the right rear side panel. A Sony audio cassette tape recorder with an "on/off" switch was mounted in the left console (Figure B7) to record the physiological data collected during the flight. Sensing

devices were placed on test pilots with electrical leads attached to a plug-in connector on the right side panel of the aircraft.

Aircraft parameters measured and recorded for use by USAFSAM/VNL, Brooks AFB, Texas, and the Swedish Air Force are listed in Table B2.

**Table B2**

**AIRCRAFT DATA TAPE CODES AND PARAMETERS**

Code	Parameter
- PD010	- Calibrated airspeed
- PD011	- Pressure altitude
- PD013	- Mach number
- AB023	- Normal acceleration
- BD100	- LIFEDATA PCM channel
- MD128	- Voice
- XX006	- Anti-g suit ready pressure
- XX005	- Oxygen regulator pressure
- XX004	- PBG (mask) flow meter
- IID001	- IRIG "B"

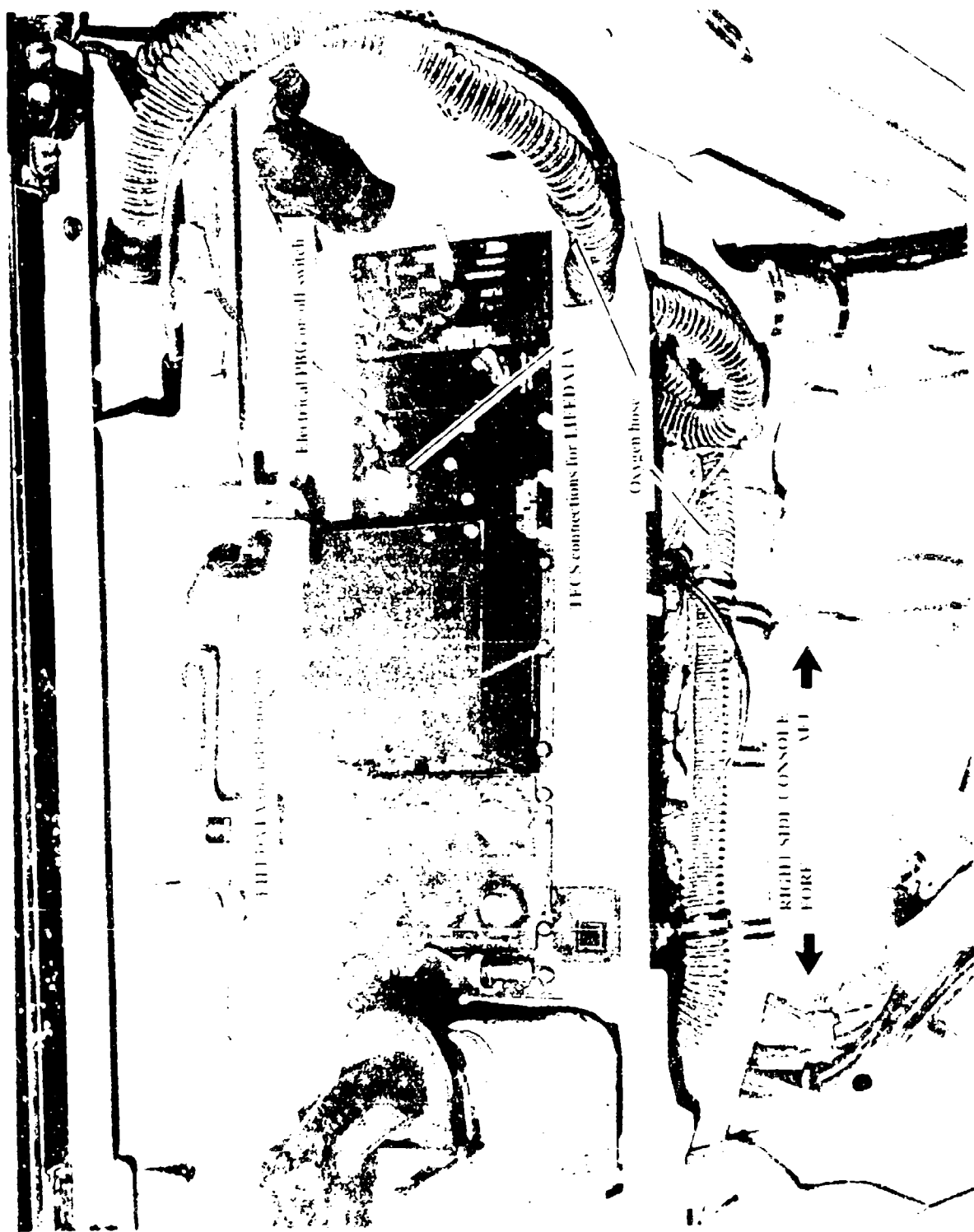


Figure 100. Cockpit Location of LIFE DATA Circuit Board Bay



Fig. 1. Cockpit interior of F-105A from Korea.

**APPENDIX C**  
**FLIGHT TEST MATRIX AND PROCEDURES**

**Table C1**

**TEST FLIGHT MATRIX**

Pilots	FCF	Baseline	FAM	High-g/ Duration	ACM/BFM	Ensemble
AFPTC A	1		1 2	1	1	F-16/PBG TFCS
AFPTC B	1	2*	2	1		F-16/PBG TFCS
AFPTC C			2	1	2	F-16/PBG TFCS
SAF 1		1*	1** 2	1	1	TFCS TFCS
SAF 2		1*	1** 1	2	2	TFCS TFCS

NOTES: Numbers represent number of flights per pilot.  
 \* Pilots flew with standard anti-g suit, CSU-13B/P.  
 \*\* Pilots flew with PBG off.

## PROCEDURES FOR FLIGHT TEST

### **G-1 G WARM-UP MANEUVER**

Perform 4 g and 7 g turns for the g warm-up maneuver before commencing the test runs.

### **G-2 SUSTAINED G TURN**

Perform a turn at the target g level. Hold g's through 180 degree heading change.

### **G-3 WIND-UP TURNS**

Initiate a turn. Increase load factor at a rate of 2 g/sec to target g and hold for 10 seconds.

### **G-4 ABRUPT PULL-UP**

Perform an abrupt, full aft stick pull-up, recovering at 60 degrees of pitch or 250 KCAS, whichever occurs first.

### **G-5 TURN REVERSAL**

Begin a turn at the indicated g level, altitude and airspeed. Perform an abrupt turn reversal, not exceeding the A/C asymmetric limit.

### **G-6 SLICE-BACK**

Establish initial conditions. With power set for level flight, roll to 135 degrees of bank and abruptly apply aft stick as necessary to maintain 6 g's. Hold for 180 degrees of heading change.

### **G-7 OFFENSIVE PERCH (LOW SPEED)**

Low speed offensive perch engagements will occur at altitudes as required to stay above 5000 AGL, at speeds ranging from 250 knots to 350 knots, and at normal acceleration levels ranging from 4 to 6 g's with the test A/C attacking a cooperative target. The target A/C will turn on the test A/C's call. The test A/C will use whatever maneuvers are needed to close for simulated missile shot (FOX II). The exercise will be terminated if neutrality between A/C is achieved or there are two successive valid shots.

### **G-8 OFFENSIVE PERCH (HIGH SPEED)**

High speed offensive perch engagements will occur at altitudes as required to stay above 5000 AGL, at speeds ranging from 400 knots to 550 knots, and at normal acceleration levels ranging from 6 to 9 g's with the test A/C attacking a cooperative target. The target A/C will turn on the test A/C's call. The test A/C will use whatever maneuvers are needed to close for simulated tracking guns shot. The exercise will be terminated if neutrality between A/C is achieved or there are two successive valid shots.

## **PROCEDURES FOR FLIGHT TEST (Concluded)**

### **G-9 DEFENSIVE PERCH (LOW SPEED)**

Low speed defensive perch engagements will occur at altitudes as required to stay above 5000 AGL, at speeds ranging from 250 knots to 350 knots, and at normal acceleration levels ranging from 4 to 6 g's with a cooperative target A/C attacking the test A/C. On the target A/C's call, it will attempt to close on the test A/C for simulated missile shot (Fox II). The test A/C will use whatever maneuvers are necessary to negate the attack. The exercise will be terminated if neutrality between A/C is achieved or there are two successive valid shots.

### **G-10 DEFENSIVE PERCH (HIGH SPEED)**

High speed defensive perch engagements will occur at altitudes as required to stay above 5000 AGL, at speeds ranging from 400 knots to 550 knots, and at normal acceleration levels ranging from 6 to 9 g's with a cooperative target A/C attacking the test A/C. On the target A/C's call, it will attempt to close on the test A/C for simulated tracking guns shot. The test A/C will use whatever maneuvers are necessary to negate the attack. The exercise will be terminated if neutrality between A/C is achieved or there are two successive valid shots.

### **G-11 NEUTRAL ENGAGEMENT**

Neutral engagements will occur at altitudes as required to stay above 5000 AGL, at speeds ranging from 250 knots to 550 knots, and at normal acceleration levels ranging from 4 to 9 g's with a cooperative target A/C. On the test A/C's call, the two A/C will separate and begin the engagement as prebriefed. Each A/C will maneuver as required to gain the advantage for either simulated missile shot (Fox II) or tracking guns shot. Each A/C will use whatever maneuvers are necessary to negate the maneuvers of the attacking A/C. The exercise will be terminated if neutrality between A/C is achieved or there are two successive valid shots.

**FLIGHT TEST CONDITIONS**  
**ALL FAME FLIGHTS AND THE FCE**

Run No.	Conditions	Maneuver	Procedures
1	4 g's/7 g's	g Warm-Up	G-1
2	3 g's/0.8M	Sustained g Turn	G-2
3	5 g's/0.8M	Sustained g Turn	G-2
4	7 g's/0.8M	Sustained g Turn	G-2
5	8 g's/0.8M	Sustained g Turn	G-2
6	9 g's/0.9M	Sustained g Turn	G-2
7	7 g's/0.8M	Wind-Up Turn	G-3
8	8 g's/0.8M	Wind-Up Turn	G-3
9	Max g/0.8M	Abrupt Pull-Up	G-4
10	Max g/0.9M	Abrupt Pull-Up	G-4
11	3 g's/0.5M	Turn Reversal	G-5
12	4 g's/0.5M	Turn Reversal	G-5
13	6 g's/0.8M	Slice Back	G-6

**NOTES:**

1. Maintain Mach and altitude as required to sustain desired g-level.
2. Except for optional wingtip missiles, all stations clean.
3. Check "six" often to establish baseline for future comparisons.
4. Air refuel as required.

# ACM/BEM

Run No.	Conditions	Maneuver	Procedures
1	4 g's/7 g's	g Warm-Up	G-1
2	4-6 g's	Offensive Perch (Low Speed)	G-7
3	6-9 g's	Offensive Perch (High Speed)	G-8
4	4-6 g's	Defensive Perch (Low Speed)	G-9
5	6-9 g's	Defensive Perch (High Speed)	G-10
6	4-9 g's	Neutral Engagement	G-11

## NOTES:

1. All maneuvers will be terminated so that the A/C will be recovered to level flight by 5,000 AGL.
2. Maintain Mach and altitude as required to sustain desired g-level.
3. Except for optional wingtip missiles, all stations clean.
4. Prebrief all "knock it off" criteria.
5. Air refuel as required.
6. Repeat engagements as necessary.
7. All runs targeted for one successful completion; repeat run 6 a maximum of four (4) times.

# HIGH-G/DURATION (TARGET 2+HRS)

Run No.	Conditions	Maneuver	Procedures
1	4 g's/7 g's	g Warm-Up	G-1
2	7 g's/0.8M	Sustained g Turn	G-2
3	7 g's/0.9M	Sustained g Turn	G-2
4	8 g's/0.8M	Sustained g Turn	G-2
5	8 g's/0.9M	Sustained g Turn	G-2
6	9 g's/0.9M	Sustained g Turn	G-2
7	6 g's/0.8M	Slice Back	G-6
8	7 g's/0.8M	Wind-Up Turn	G-3
9	8 g's/0.8M	Wind-Up Turn	G-3
10	Max g/0.8M	Abrupt Pull-Up	G-4
11	Max g/0.9M	Abrupt Pull-Up	G-4
12	3 g's/0.5M	Elevated g Roll	G-5
13	4 g's/0.5M	Elevated g Roll	G-5

## NOTES:

1. Repeat runs 2 through 13 as often as necessary to attain target time.
2. Mission duration targeted for more than 2 hours but should not exceed 2.2 hours.
3. Maintain Mach and altitude as required to sustain desired g-level.
4. Except for optional wingtip missiles, all stations clean.
5. Check "six" as required.
6. Air refuel as required.
7. Rest as needed between test runs.
8. If fatigued prior to completing card, "knock it off" and return to base.
9. Provision for water in a plastic water bottle.

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**APPENDIX D**  
**SUBJECTIVE QUESTIONNAIRES AND RESPONSES**

EVALUATION OF SYSTEM DESIGN AND INTEGRATION QUESTIONNAIRE

PILOT ID \_\_\_\_\_  
(initials)

DATE \_\_\_\_\_  
(day/month/year)

\*\*\*\*\*  
\* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCS TO THE \*  
\* F-16/PBG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
\* COMMENTS ARE ENCOURAGED. \*  
\*\*\*\*\*

1. EASE OF DONNING LOWER BODY ANTI-G GARMENT/WEAR PROTECTIVE TROUSERS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9 \_ \_ \_  
Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

2. EASE OF PUTTING ON AND LACING YOUR FLIGHT BOOTS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9 \_ \_ \_  
Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

3. FIT OF YOUR FLIGHT BOOTS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9 \_ \_ \_  
Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

4. EASE OF DONNING THE UPPER BODY G-VEST.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9 \_ \_ \_  
Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

\*\*\*\*\*  
 \* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCS TO THE \*  
 \* F-16/PDG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
 \* COMMENTS ARE ENCOURAGED. \*  
 \*\*\*\*\*

5. EASE OF DORNING THE HELMET AND MASK.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

6. EASE OF DORNING YOUR PARACHUTE HARNESS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

7. EASE OF DOFFING (UNDRESSING) THE TFCS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

8. ABILITY TO BEND AT THE WAIST AND FLEX HIP AND KNEE JOINTS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

9. ABILITY TO FLEX AND EXTEND UPPER EXTREMITIES.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

\*\*\*\*\*  
 \* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCS TO THE \*  
 \* F-16/PDG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
 \* COMMENTS ARE ENCOURAGED. \*  
 \*\*\*\*\*

10. ABILITY TO PERFORM THE PRE-FLIGHT GROUND INSPECTION.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

11. EASE OF INGRESSING THE FCP.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

12. EASE OF INGRESSING THE ACP.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

13. EASE OF SECURING LAP BELT AND CABLE/HOSE CONNECTIONS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

14. ABILITY TO LOWER CANOPY AND PERFORM APPROPRIATE COCKPIT CHECKS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

\*\*\*\*\*  
 \* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCS TO THE \*  
 \* F-16/PDG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
 \* COMMENTS ARE ENCOURAGED. \*  
 \*\*\*\*\*

15. LIMITATIONS TO COCKPIT FIELD OF VIEW (TO SUPPLEMENT FOV WORKSHEET).

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse                      Worse                      Same                      Better                      Much better

COMMENTS: Visor distortion? YES NO (circle one)  
 Glare/reflection? YES NO

16. EASE OF ACCOMPLISHING POST-FLIGHT PROCEDURES.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

17. EASE OF EGRESSING THE FCP.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

18. EASE OF EGRESSING THE ACP.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

19. ABILITY TO ACCOMPLISH EMERGENCY GROUND EGRESS FROM FCP.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse                      Worse                      Same                      Better                      Much better

COMMENTS:

\*\*\*\*\*  
 \* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCS TO THE \*  
 \* F-16/PBG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
 \* COMMENTS ARE ENCOURAGED. \*  
 \*\*\*\*\*

20. ABILITY TO ACCOMPLISH EMERGENCY GROUND EGRESS FROM ACP.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

21. OVERALL COMFORT OF THE TFCS OUTSIDE THE COCKPIT.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

22. OVERALL COMFORT OF THE TFCS WHILE SEATED IN THE COCKPIT.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

23. LIST AREAS OF NOTICABLE PINCHING OR BINDING FROM THE TFCS.

24. PERCEIVED LEVEL OF SWEATING IN THE TFCS.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
 Much worse Worse Same Better Much better

COMMENTS:

Table D1

# **EVALUATION OF SYSTEM DESIGN AND INTEGRATION QUESTIONNAIRE - REE SUMMARY**

## **Rating Scale**

1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7 - - - - 8 - - - - 9  
 Much Worse                      Worse                      Same                      Better                      Much Better

Question No.	Pilot A	Pilot B
1. Donning anti-g/immersion suit	3	3
2. Donning flight boots	3	3
3. Fit of flight boots	1	5
4. Donning anti-g vest	7	5
5. Donning helmet mask	8	4
6. Donning parachute harness	3	5
7. Doffing TFCS	3	-
8. Lower body mobility	4	3
9. Upper body mobility	5	4
10. Preflight inspection	5	4
11. Ingressing front cockpit	4	1
12. Ingressing rear cockpit	4	-
13. Securing connections	4	4
14. Cockpit checks	-	3
15. Cockpit field of view	5	5
16. Preflight procedures	5	5

## **NOTES:**

1. For question 15, fields of view were rated the same because of the wear protective trousers.
2. Dashes indicate no response.

**Table D1 (Concluded)**

**EVALUATION OF SYSTEM DESIGN AND INTEGRATION QUESTIONNAIRE - RESPONSE  
SUMMARY**

**Rating Scale**

1 . . . . 2 . . . . 3 . . . . 4 . . . . 5 . . . . 6 . . . . 7 . . . . 8 . . . . 9  
 Much Worse                      Worse                      Same                      Better                      Much Better

Question No.	Pilot A	Pilot B
17. Egressing front cockpit	4	3
18. Egressing rear cockpit	4	3
19. Emergency ground egress - front	5	5
20. Emergency ground egress - rear	5	5
21. Comfort outside cockpit	3	4
22. Comfort inside cockpit	5	5
23. Areas of pinching/binding	none	none
24. Sweating	5	5

# TFCS FUNCTIONAL EVALUATION QUESTIONNAIRE

PILOT ID \_\_\_\_\_ DATE \_\_\_\_\_  
(initials) (day/month/year)

\*\*\*\*\*  
\* ANSWER THE FOLLOWING QUESTIONS BY \*  
\* CIRCLING THE APPROPRIATE RATING. \*  
\* COMMENTS ARE ENCOURAGED. \*  
\*\*\*\*\*

1. DID THE OXYGEN REGULATOR FUNCTION NORMALLY WITH THE RED AND WHITE LEVERS SET IN THEIR USUAL CONFIGURATION FOR ROUTINE TAKE-OFF? Yes No
  
2. DID THE OXYGEN REGULATOR FUNCTION NORMALLY AT EACH OF THE FOUR TEST SETTINGS LISTED BELOW?
 

a. RED LEVER - up, WHITE LEVER - down	Yes	No
b. RED LEVER - up, WHITE LEVER - up	Yes	No
c. RED LEVER - down, WHITE LEVER - down	Yes	No
d. RED LEVER - down, WHITE LEVER - up	Yes	No
  
3. WITH THE G-VALVE ACTIVATED ("PRESS TO TEST" BUTTON DEPRESSED), DID THE OXYGEN REGULATOR DELIVER A NOTICABLY GREATER FLOW OF OXYGEN INTO THE MASK?
 

a. RED LEVER - up, WHITE LEVER - down	Yes	No
b. RED LEVER - up, WHITE LEVER - up	Yes	No
c. RED LEVER - down, WHITE LEVER - down	Yes	No
d. RED LEVER - down, WHITE LEVER - up	Yes	No
  
4. WAS THERE ANY NOTICABLE INTERFERENCE OR UNUSUAL DEVIATIONS OF INSTRUMENT READINGS FROM ROUTINE PRE-FLIGHT SETTINGS? Yes No

If so, please identify them specifically below.

5.	DID THE BLOWER VENTILATE THE TFCS UNIFORMLY TO ALL PARTS OF YOUR BODY?	Yes	No
	If not, identify specific hot/cold areas.		
6.	COULD YOU ADJUST THE AMOUNT OF AIR BEING BLOWN INTO THE TFCS (LEVEL OF VENTILATION)?	Yes	No
7.	DID THE BLOWER ITSELF DISTRACT YOU IN ANY WAY?	Yes	No
8.	IDENTIFY YOUR PERCEIVED LEVEL OF SWEATING JUST PRIOR TO COCKPIT EGRESS.	Dry	
		Mildly Damp	
		Damp	
		Wet	
		Soaking Wet	

**Table D2**

**TFCS FUNCTIONAL EVALUATION QUESTIONNAIRE - RESPONSE SUMMARY (BOTH PILOTS)**

1. Did the oxygen regulator function normally with the red and white levers set in their usual configuration for routine takeoff? Yes
  
2. Did the oxygen regulator function normally at each of the four test settings listed below?
 

a. red lever - up	white lever - down	Yes
b. red lever - up	white lever - up	Yes
c. red lever - down	white lever - down	Yes
d. red lever - down	white lever - up	Yes
  
3. With the g-valve activated ("Press to Test" button depressed), did the oxygen regulator deliver a noticeably greater flow of oxygen into the mask?
 

a. red lever - up	white lever - down	No
b. red lever - up	white lever - up	No
c. red lever - down	white lever - down	No
d. red lever - down	white lever - up	No
  
4. Was there any noticeable interference or unusual deviations of instrument readings from routine preflight settings? Yes

If so, please identify them specifically below. \*See Field of View
  
5. Did the blower ventilate the TFCS uniformly to all parts of your body? Yes

If not, identify specific hot/cold areas.
  
6. Could you adjust the amount of air being blown into the TFCS (level of ventilation)? Yes
7. Did the blower itself distract you in any way? Yes
8. Identify your perceived level of sweating just prior to cockpit egress. Mildly damp

# FLIGHT TEST QUESTIONNAIRE

PILOT ID \_\_\_\_\_ DATE \_\_\_\_\_  
(initials) (day/month/year)

SORTIE \_\_\_\_\_  
(number)

\*\*\*\*\*  
\* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCs TO THE \*  
\* F-16/PDG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
\* COMMENTS ARE ENCOURAGED. \*  
\*\*\*\*\*

## 1. PERCEIVED LEVEL OF ANTI-G PROTECTION.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
Much worse Worse Same Better Much better

COMMENTS:

## 2. MASK LIMITATIONS TO INSIDE COCKPIT FIELD OF VIEW.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
Much worse Worse Same Better Much better

COMMENTS:

## 3. MASK LIMITATIONS TO OUTSIDE COCKPIT FIELD OF VIEW.

1 \_ \_ \_ 2 \_ \_ \_ 3 \_ \_ \_ 4 \_ \_ \_ 5 \_ \_ \_ 6 \_ \_ \_ 7 \_ \_ \_ 8 \_ \_ \_ 9  
Much worse Worse Same Better Much better

COMMENTS:

\*\*\*\*\*  
 \* ANSWER THE FOLLOWING QUESTIONS BY COMPARING THE TFCS TO THE \*  
 \* F-16/PBG ENSEMBLE. PLEASE CIRCLE THE APPROPRIATE NUMBER. \*  
 \* COMMENTS ARE ENCOURAGED. \*  
 \*\*\*\*\*

4. EASE OF "CHECKING SIX".

1 \_ 2 \_ 3 \_ 4 \_ 5 \_ 6 \_ 7 \_ 8 \_ 9 \_  
 Much worse Worse Same Better Much better

COMMENTS:

5. LIMITATIONS FOR REACHING AND OPERATING COCKPIT SWITCHES AND CONTROLS.

1 \_ 2 \_ 3 \_ 4 \_ 5 \_ 6 \_ 7 \_ 8 \_ 9 \_  
 Much worse Worse Same Better Much better

COMMENTS:

6. OVERALL COMFORT DURING THE FLIGHT.

1 \_ 2 \_ 3 \_ 4 \_ 5 \_ 6 \_ 7 \_ 8 \_ 9 \_  
 Much worse Worse Same Better Much better

COMMENTS:

7. POINTS OF PINCHING/BINDING OR MINOR PAIN.

1 \_ 2 \_ 3 \_ 4 \_ 5 \_ 6 \_ 7 \_ 8 \_ 9 \_  
 Much worse Worse Same Better Much better

COMMENTS:

8. OVERALL COMFORT OF THE HELMET

1 \_ 2 \_ 3 \_ 4 \_ 5 \_ 6 \_ 7 \_ 8 \_ 9 \_  
 Much worse Worse Same Better Much better

COMMENTS:

\*\*\*\*\*  
 \*                   ANSWER THE FOLLOWING QUESTIONS BY                   \*  
 \*                   CIRCLING THE APPROPRIATE RATING.                   \*  
 \*                   COMMENTS ARE ENCOURAGED.                   \*  
 \*\*\*\*\*

9. WERE THERE ANY HOSES OR CORDS YOU WOULD  
 CONSIDER AS RESTRICTIVE TO YOUR RANGE OF  
 MOTION IN THE COCKPIT?                   Yes   Somewhat   No

COMMENT:

10. DID YOU NOTICE ANY HELMET "HOT SPOTS"  
 ON THIS SORTIE?                   Yes   Somewhat   No

COMMENT:

11. WERE YOU DISTRACTED BY ANY IRRITATING  
 AREAS OF EXCESSIVE ITCHING?                   Yes   Somewhat   No

COMMENT:

12. DID THE BLOWER VENTILATE THE TFCS UNIFORMLY  
 TO ALL PARTS OF YOUR BODY THROUGHOUT THE  
 FLIGHT?                   Yes   Somewhat   No

If not, identify specific hot/cold areas.

13. COULD YOU ADJUST THE AMOUNT OF AIR BEING  
 BLOWN INTO THE TFCS (LEVEL OF VENTILATION)  
 DURING THE FLIGHT?                   Yes   Somewhat   No

14. DID THE BLOWER ITSELF DISTRACT YOU IN ANY WAY?                   Yes   Somewhat   No

\*\*\*\*\*  
 \* THE FOLLOWING QUESTIONS ARE TO BE ANSWERED \*  
 \* AT THE COMPLETION OF FLIGHT TEST. \*  
 \*\*\*\*\*

15. IDENTIFY YOUR PERCEIVED LEVEL OF SWEATING JUST  
 PRIOR TO COCKPIT EGRESS.

Dry  
 Mildly Damp  
 Damp  
 Wet  
 Soaking Wet

16. WOULD YOU LIKE TO FLY IN THE TFCS ON EVERY  
 HIGH-G OR ACM/BFM SORTIE?

Yes No

17. WHAT DID YOU LIKE THE MOST ABOUT THE TFCS?

18. WHAT DID YOU LIKE THE LEAST ABOUT THE TFCS?

19. IN YOUR JUDGEMENT, IS THERE ANY DESIGN FEATURE OF THE TFCS WHICH MAY  
 INADVERTENTLY PLACE A PILOT IN AN UNSAFE SITUATION THAT DOESN'T EXIST  
 WITH CURRENT FLIGHT GEAR?

20. ON HOW MANY SORTIES DID YOU EXPERIENCE GREY OUT (LIGHT LOSS)? \_\_\_\_\_  
 WHAT WAS THE ESTIMATED % (PER CENT) LIGHT LOSS? \_\_\_\_\_

Table D3

## FLIGHT TEST QUESTIONNAIRE - RESPONSE SUMMARY

## Rating Scale for Questions 1-8

1 . . . . . 2 . . . . . 3 . . . . . 4 . . . . . 5 . . . . . 6 . . . . . 7 . . . . . 8 . . . . . 9  
 Much Worse                      Worse                      Same                      Better                      Much Better

Question No.	Pilot A					Pilot B						Pilot C			
	Flight No.					Flight No.						Flight No.			
	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4
1. Anti-g protection	8	3	8	8	8	3	7	7	7	7	7	7	7	5	6
2. Inside field of view	7	8	7	8	8	7	3	3	-	-	-	-	-	-	-
3. Outside field of view	6	6	6	6	6	5	5	5	-	-	-	-	-	-	-
4. Ease of checking six	6	6	6	6	7	3	3	3	3	3	4	3	3	3	4
5. Reach in cockpit	4	3	3	4	4	3	3	3	3	3	3	3	3	3	3
6. Overall comfort	6	7	7	7	7	7	6	5	5	3	6	6	4	4	4
7. Pinching/binding	5	7	7	8	8	3	3	5	5	3	6	3	5	5	3
8. Helmet comfort	7	8	7	8	8	5	5	5	-	-	-	-	-	-	-

## NOTES:

1. Dashes indicate no response.
2. All TFCS flights.
3. Pilot B, flight 1, PBG failure.
4. Pilot A, flight 2, PBG failure.

Table D3 (Continued)

## FLIGHT TEST QUESTIONNAIRE - RESPONSE SUMMARY

## Rating Scale for Questions 9-14

1 . . . . . 2 . . . . . 3  
 Yes                  Somewhat                  No

Question No.	Pilot A					Pilot B						Pilot C			
	Flight No.					Flight No.						Flight No.			
	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4
9. Mobility restriction	3	3	3	3	3	3	3	3	3	3	1	1	3	1	3
10. Helmet hot spots	3	3	3	3	3	3	3	3	-	-	-	-	-	-	-
11. Itching	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12. Uniform ventilation	3	1	1	2	2	3	3	2	2	2	2	2	2	3	2
13. Ventilator adjustable	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1
14. Blower distracting	3	3	3	3	3	3	3	3	3	3	3	3	3	1	2

## NOTES:

1. Dashes indicate no response.
2. All TFCS flights.

Table D3 (Concluded)

## FLIGHT TEST QUESTIONNAIRE - RESPONSE SUMMARY

Question No.	Pilot A					Pilot B						Pilot C			
	Flight No.					Flight No.						Flight No.			
	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4
15. Level of sweating	damp	*	*	*	*	*	*	dry	*	*	*	dry	dry	*	*
16. Always use TFCS	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	no	no
17. Like most about TFCS	-g protection-					-g protection-						-g protection-			
18. Like least about TFCS	-bulk-					-bulk-						-bulk-			
19. Unsafe features	-no-					-no-						-no-			
20. Vision light loss	no	yes	no	no	no	yes	no	yes	yes	yes	no	yes	no	yes	yes

## NOTES:

1. The "\*" indicates mildly damp.
2. Pilot A, flight 2, slight tunnel vision when TFCS PBG failed.
3. Pilot B, tunnel vision.
4. Pilot C, slight tunnel vision.
5. Pilot C felt one should not commit to "always."

## LIST OF ABBREVIATIONS

<u>Abbreviation</u>	<u>Definition</u>	<u>Unit</u>
A/C	aircraft	...
ACM	air combat maneuvering	...
AFB	Air Force Base	...
AFFTC	Air Force Flight Test Center	...
AGL	above ground level	...
BFM	basic fighter maneuver	...
CAF	Canadian Air Force	...
F-16/PBG	F-16 pressure breathing for g's flight suit	...
FAM	familiarization flight	...
FCF	functional check flight	...
GLOC	g-induced loss of consciousness	...
g	acceleration due to gravity	...
HUD	head-up display	...
HSD	Human Systems Division	...
K	one thousand	feet
KCAS	knots calibrated airspeed	...
KIO	knock it off	...
LIFEDATA	physiological data collection system	...
M	Mach number	...
mm Hg	pressure in millimeters of mercury	millimeters
msl	mean sea level	...
O <sub>2</sub>	oxygen	...
PBG	pressure breathing for g's	...
PCM	pulse code modulation	...

## LIST OF ABBREVIATIONS (Concluded)

<u>Abbreviation</u>	<u>Definition</u>	<u>Unit</u>
psi	pressure in pounds per square inch	inch <sup>2</sup>
SAF	Swedish Air Force	---
S/N	serial number	---
TAF	Tactical Air Force	---
TFCS	Tactical Flight Combat Suit	---
TIS	test information sheet	---
USAF	United States Air Force	---
USAFSAM	United States Air Force School of Aerospace Medicine	---
WPT	wear protective trousers	---
WUT	windup turn	---

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DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS 412TH TEST WING (AFMC)  
EDWARDS AIR FORCE BASE, CALIFORNIA

20 May 2004

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER  
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SUBJECT: Distribution Statement Revision (AD B139 099)

1. The following report distribution statement has been changed from ``Further dissemination only as directed by HSD/YAL, Brooks AFB, TX 78235-1503'' to ``Public Release; distribution unlimited.''

AFFTC TR 89-38

Limited evaluation of the tactical flight combat suit in the F-16, by George B. Kemper. December 1989.

2. The report distribution statement revision was coordinated with 311 HSW/YA, the Swedish government, and the F-16 CTF POC. Please see the attached documentation from the Air Force Flight Test Center Public Affairs Office, clearing the report for public release (AFFTC/PA #04116, dated 12 May 2004).

3. If there are any questions, please contact me at DSN 527-3606 or (661) 277-3606.

  
JOLAINE LAMB  
AFFTC STINFO

Attachment:  
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1. In accordance with AFI 61-204, as supplemented by AFFTCI 61-2, and AFI 35-101, Chapter 15, public release approval is requested for the following:

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Title: AFFTC-TR-89-38, Limited Evaluation of the Tactical Flight Combat Suit in the F-16, by Georgy B. Kemper and Alain B. Lacharite, December 1989.

Submittal deadline: None

Meeting/Date/Place: For Public Release

2. It was prepared:

In-house Author/Office Sym/Phone: Marc Trinklein (F-16 POC) 7-2805 and Ed George (Human Factors POC) 77190, ext 2297. The controlling office for this report is the 311 HSW/YAPA and the POC is James F. Gough, Chief, Aircrew Protection Branch, Brooks City-Base TX. This report was originally written as a joint effort with the Swedish government. Mr. Gough has obtained their concurrence that it is suitable for public release. Mr. Gough requested that it go through the AFFTC security and policy review process.

3. The author has stated the attached document is unclassified, does not contain sensitive unclassified information, and does not violate contractor propriety rights (if appropriate). The report is already in DTIC (ADB 139 099).

*George Ka'iliwai III*  
 GEORGE KA'ILIWAI III, SL  
 Technical Advisor

Attachment:  
 Sensitive Data Memo  
 Technical Report

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